A Textbook on

Ancient History of Indian Agriculture

RC Saxena

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YL Nene

ASIAN AGRI-HISTORY FOUNDATION 1994 कृषिमित् कृषस्व

Asian Agri-History Foundation (AAHF), Secunderabad

Rajasthan Chapter of AAHF, Udaipur

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Foreword

The Asian Agri-History Foundation (AAHF), a non-profit trust, was established and registered in Secunderabad in 1994 with major objectives to unearth original documents that contained information on ancient and medieval agriculture of Asia and disseminate such information worldwide.

The AAHF has so far published 8 classics on agriculture including biology. These are: Vrikshayurveda (The Science of Plant Life) by Surapala (c. 1000 AD); Krishi-Parashara by Parashara (c. 400 BC); Nuskha Dar Fanni-Falahat (The Art of Agriculture), a Persian manuscript by Dara Shikoh (1650 AD); Kashyapiyakrishisukti (A Treatise on Agriculture) by Kashyapa (c. 800 AD); Vishvavallabha (Dear to the World: The Science of Plant Life) by Chakrapani Mishra (1577 AD); Lokopakara (For the Benefit of People) by Chavundaraya (1025 AD); Krishi Gita (Agricultural Verses), Advice on Agriculture by Parasurama (c.15th century AD); and Mriga.pakshi.shastra (The Science of Animals and Birds) by Hamsadeva (13th century AD). With information published by the AAHF during the past 14 years, many unknown facts about India's rich agricultural heritage have been brought to light.

In 2007, YL Nene's 900-page edited book, "Glimpses of the Agricultural Heritage of India", was published by the AAHF with the aim of providing information to teachers and students of agricultural colleges and universities all over India. This book was brought out because of two reasons: (i) in a conference of the Vice-Chancellors (VCs) of agricultural universities in April 2003, it was resolved that a course on agricultural heritage of India will be introduced in the undergraduate curricula of agricultural universities and colleges from 2004 academic year; and (ii) no textbook or resource book on agricultural heritage was available that could be used by teachers and students to obtain authentic information. During the same period, a Deans' Committee on courses and curricula appointed by the Indian Council of Agricultural Research (ICAR) came up with recommendations that more or less ignored the 2003 resolution of the VCs. The Deans' Committee was so obsessed with the modern catch-phrases such as sustainable agriculture, biotechnology, etc. that it decided to ignore teaching agricultural heritage. This was indeed very disappointing because the Committee failed to appreciate that without the knowledge of our own rich agricultural past, we would never be able to truly help the majority of Indian farmers in increasing agricultural productivity. I sincerely hope better sense will prevail and in the near future VCs will use the 'autonomy' to introduce courses on agricultural heritage in undergraduate curricula of their respective universities. I may point out, however, that only two or three universities have introduced the courses on agri-heritage halfheartedly.

Further we ourselves realized that the 900-page book can only serve as a resource book and not a textbook. Therefore some members of the Rajasthan Chapter of AAHF felt that a textbook,

based on the contents prescribed by the AAHF, should be written especially for students. Thus Late Dr RC Saxena and Dr SL Choudhary began work on writing the textbook. After making substantial progress, Dr Saxena passed away suddenly. This was indeed a very sad happening and caused a setback to the work. At this stage Dr YL Nene joined Dr Choudhary to complete the task. The Rajasthan Chapter of AAHF and the AAHF Headquarters have jointly financed this publication.

We sincerely hope this book will introduce readers, especially undergraduate students of agriculture, to information on Indian agricultural heritage.

October 2009

YL Nene
Chairman
AAHF

Preface

When the British introduced formal education in India, more than a century ago, they emphasized that "the scientific" agriculture originated only in the West and the Indian farming systems have always been "unscientific". It is unfortunate that the course curriculum in agriculture till today reflects the Western bias. It is only during the past three decades, the West itself has recognized that many of the present "scientific" practices led to unsustainable agriculture, and only then did Indian scientists study the traditional/indigenous farming systems.

The Indian Council of Agricultural Research (ICAR), New Delhi, in the conference of the Vice-Chancellors of agricultural universities held on April 1, 2003 resolved that a course on "Agricultural Heritage of India" will be introduced in the undergraduate curricula of agricultural universities and colleges from 2004. All the Vice-Chancellors, who attended this conference, appreciated the contributions made by Asian Agri-History Foundation (AAHF), Secunderabad and its Rajasthan Chapter for publication of ancient manuscripts after translation into English as well as for publication of the journal Asian Agri-History since 1997. The Rajasthan Chapter of AAHF has also organized several conferences and seminars in different parts of the country to collect more information on our heritage in the field of agriculture to document them. Further two workshops for prospective teachers of agricultural heritage were held at National Academy of Agricultural Research Management (NAARM), Hyderabad. It is disappointing, however, that only very few universities have so far introduced this course. The major constraint was the unavailability of a resource book. Hence Dr YL Nene, Chairman, AAHF, Secunderabad edited and published a 900-page book entitled "Glimpses of the Agricultural Heritage of India" in 2007.

Based on the prescribed course curricula, we have made efforts to prepare a textbook on this subject entitled "A Textbook on Ancient History of Indian Agriculture" for the undergraduates. We hope after going through this book, students would be motivated and realize the contributions of our ancestors in the field of agriculture. This book contains 19 chapters, each chapter carrying a few questions at the end. We hope this book would be helpful to the students, teachers, and others as well.

The senior author, Dr RC Saxena, unfortunately passed away suddenly on 4 May 2008 after having done substantial work on the book. We shall miss him as an excellent colleague and as a person dedicated to the activities of the AAHF.

We are highly grateful to AAHF and its trustees for their encouragement and for providing the relevant literature and other facilities to compile this book. We also acknowledge the cooperation

provided by Drs Asha Singhal and Dhriti Solanki, College of Home Science, Udaipur and Drs MM Simlot, Arunabh Joshi, and Rakesh Shah, Rajasthan College of Agriculture, Udaipur. We also express our sincere thanks to Ms Sheila Vijayakumar for the editing, Mr SM Sinha for art direction and printing supervision, Ms Salai Muthu for general assistance, and Mr Ch Vengala Reddy for DTP work.

SL Choudhary
YL Nene

CHAPTER 1

HISTORICAL DEVELOPMENT OF HUMAN CULTURE

History is an ancient Greek word meaning knowing or learned. History is a branch of literature, which deals with the progress, prosperity, skills, downfalls, and lapses of a nation, caste, or creed. It is of paramount importance because by experiencing the lapses of the past, one makes efforts not to repeat them in future and to continue those activities, which had been beneficial in the past.

In nature, life does not disappear without leaving traces. These traces are found in the form of fossils. By studying these traces scientists explore the past. On the basis of these traces, it has been shown that people had lived for about two million years ago on the Earth.

Fossil

A fossil (in Latin – something dug up) is an evidence of animal or plant, which is seen in the stratum layers of the earth's crust and which lived a long time ago. Fossils not only include the bones, shells, teeth, and other hard parts of an animal (or parts of any organism), which survived during that period, but also the impressions and traces left by those organisms.

Rock Strata

The rock strata of the earth include sedimentary and igneous rocks. By the process of erosion through the action of rain, wind, freezing, and thawing, rocks are gradually broken into small particles that form soil. The particles of the soil are carried through rains into the streams, rivers, and ultimately into water bodies, like lakes and oceans, where these are deposited. The sedimentary deposit, owing to the pressure of water above it and the chemical reactions, is converted into sedimentary rocks. The cooling of magma expelled from active volcanoes forms the igneous rocks.

Submergence and Emergence

Other processes occurred in the past and are occurring between land and sea. Slow and gradual process in level between land and sea are in progress. The sinking of land below the sea is called 'submergence' and the rising of land above the sea level is called 'emergence'. In the geologic past, many regions on the earth have undergone a series of submergence and emergence processes.

How was the Time Measured in Ancient Ages?

Land tillers knew that the summer, the harvest time, occurred regularly. They counted the time by periods from one harvest to the next. This was how time began to be counted by years.

Kala-Chakra

In Hindu thought, time, regarded as one which destroys all beings, is not a linear but a cyclic phenomenon. The course of time passes through Brahma's day, i.e., time span of existence of

universe and Brahma's night, i.e., time span that lapses before regeneration. This cycle of *Utpatti, Laya* – again *Utpatti, Laya* is *Kala-Chakra.*

The *Yuga* Concept

The concept of *yuga* is unique to Hindu astronomy. *Kali, Dwapara, Treta,* and *Kritayuga* are the four fundamental *yugas*. *Dwapara, Treta*, and *Kritayuga* have respectively 2, 3, and 4 times *Kaliyuga* time span.

- *Kaliyuga* 432,000 years
- *Dwaparayuga* 864,000 years
- *Tretayuga* 1,296,000 years
- *Kritayuga* 1,728,000 years

Mahayuga is the total of these four *yugas*, i.e., 4,320,000 years. This time span compares with the time of evolution of life on earth, life-forming molecules to intelligent human beings.

Manvantara is 71 *Mahayugas* + *Kritayuga*, i.e., 308,448,000 years. This time span roughly corresponds to the time taken by Sun to complete one revolution around the center of the Milky Way or Galaxy.

Kalpa is 14 *Manvantaras* + 1 *Kritayuga* or 1000 *Mahayugas*, i.e., 4,320,000,000 years. This time span compares with the age of the universe. Brahma's Day is 2 *Kalpas.*

How Old Are We?

As on *Varshapratipada* of 2000 AD (April 5, 2000), we were in the second quarter of Brahma's Day called *Shewtavarah Kalpa*, seventh *Manvantara* named *Vaivaswata* and entered into first quarter of the 28th *Kaliyuga.* Already 5,101 years of this 28th *Kaliyuga* have passed. So the time elapsed in this *Kalpa* is:

6 *Manvantaras* (6 × 308,448,000)	=	1,850,688,000 years
and		
27 *Mahayugas*	=	116,640,000 years (27 × 4,320,000)
and		
28th *Krita* + *Treta* + *Dwapara yugas*	=	3,888,000 years (9 × 432,000)
and		
5101 years of *Kaliyuga*	=	5,101 years
Total	=	1,971,221,101 years

So the year 2009 AD is:

Srishti Samvant = 1,971,221,110 years
Yugabda = 5,111 years
Vikram Samvant = 2,065 years

Important Hindu Eras

Every civilization has its own calendar for religious, historical, and chronological records. The calendar commences with an Era or *Saka*, whose starting point commemorates a great event. The most commonly used Hindu *Sakas* or Eras are *Kali*, *Vikrama*, and *Shalivahana*.

Kali Saka or *Kaliyuga*

This followed the *Dwaparayuga*, whose end is characterized by the Mahabharata war and the demise of Sri Krishna. It commenced from the midnight between 17th and 18th (Friday) February 3102 BC. The commencement of *Kaliyuga* roughly corresponds to the beginning of Indus Valley civilization.

Vikrama Saka

King Vikramaditya of Ujjain started this era to commemorate his victory over Sakas or Scythians. The *Vikrama Saka* commenced on *Kartika Shukla Pratipada,* i.e., the day after *Deepavali* in 58 BC. It is in vogue even today in Gujarat. In some other parts of North India also, *Vikrama Saka* is in vogue, with a small difference – the New Year starts from *Chaitra Shukla Pratipada.*

Shalivahana Saka

King Shalivahana of Paithan (Maharashtra) started this era in 78 AD. That *Saka* calendar started on *Chaitra Shukla Pratipada,* known as *Gudi Padava,* presently observed as New Year Day in Andhra, Karnataka, and Maharashtra. Some parts of India observe New Year on different days like *Baisakhi*, *Bihu*, etc.

Prevalent Indian eras (base: 2009)

Era and the Zero of Era		Year of Era
Kali	3102 BC	5111
Buddha-Nirvana	552 BC	2553
Mahavira-Nirvana	535 BC	2536
Vikrama (I)	57 BC	2066
Shalivahana	78 AD	1931

Ancient Man

The development of civilization had been a slow process right from Paleolithic to Modern period. The earliest period, i.e., Paleolithic period is the period of Stone Age characterized by rough or chipped stone implements. Mesolithic period is characterized by the development of the polished

stone implements. It began about 12,000 years ago and ended with the beginning of the Neolithic period about 10,000 years ago. This period is characterized by the rise of agriculture. The Chalcolithic period (2300 to 1300 BC) is characterized by development of culture.

The earliest people differed considerably from the people we see today. The ancient people resembled large apes with forehead low and retreating and having larger brain than apes but much smaller than modern man. They used to walk leaning strongly forward. Their fingers were clumsy. They were able to do only the simplest things with their hands; for example, digging the ground a little, grasping the objects, and delivering blows. They used to utter only few sounds, which expressed anger and fear. By producing such sounds they could call the other people for help and warn each other of danger as the animals do.

Implements of ancient man

Man did not have such strong paws, sharp claws, and teeth as large predators have. Therefore he used stones with sharp edges. For this purpose he split small stones into little pieces by hitting with a big stone. This stone with sharpened edges was called a hand axe, which was used to cut a bone and to sharpen the end of a stick for digging the ground. Apart from this, while breaking the bones to eat the marrow the people noticed that sharp splinters resulted. Then they also started to make awls (small oriented tool for making holes), needles, and cut harpoons (jagged spear tip which stuck in animal body) out of the bones and horns, but stone implements remained the most important for them. It was only by means of stone they could cut wood, bones, and horns. The period is called Paleolithic, which is related to the earliest period of Stone Age characterized by rough and pointed stone implements.

The hand axe and digging stick were man's first implements of labor with which he procured food. No animal can make even the simplest instrument of labor. The ability of man to make implements of labor was the principal difference of earliest man from animals. It was due to this ability that man emerged from animal kingdom more than two million years.

Activities of ancient man

Man used his brain to work hard in making tools and to determine their size and form. Also hunting people had to decide how the hunters would take their position to kill the animal. This contributed to the development of brain; its size grew and man's forehead became prominent and coherent speech developed among people. About 30,000 years ago man became similar to the people of our time.

During evolutionary process man passed mainly through three stages. These were: (i) Hunter, (ii) Gatherer, and (iii) Producer.

A hunter-gatherer society is one whose primary subsistence method involves the direct procurement of edible plants and animals from the wild, foraging and hunting without significant recourse to the domestication of either. Hunter-gatherers obtain most from gathering rather than hunting; up to 80 percent of the food is obtained by gathering. The demarcation between hunter-gatherers and other

societies which rely more upon domestication is not distinct, as many contemporary societies use a combination of both strategies to obtain the foodstuffs required to sustain themselves.

History

Hunting and gathering was presumably the subsistence strategy employed by human societies for more than two million years, until the end of the Mesolithic period. The first hunter-gatherers may have lived in mixed habitats which allowed them to collect seafood, eggs, nuts, and fruits and scavenge the occasional dead animal and in this sense were more meat scavengers than actual hunters. Rather than killing large animals themselves for meat, they used carcasses of large animals killed by other predators or carcasses from animals that died by natural cause. The transition into the subsequent Neolithic period is chiefly defined by the unprecedented development of nascent agricultural practices. Agriculture originated and spread in several different areas including the Middle East, Asia, Mesoamerica, and the Andes beginning as early as 10,000 years ago.

Many groups continued their hunter-gatherer ways of life, although their numbers have perpetually declined partly as a result of pressure from growing agricultural and pastoral communities. Many of them reside in arid regions and tropical forests in the developing world. Areas which formerly were available to hunter-gatherers were – and continue to be – encroached upon by the settlements of agriculturists. In the resulting competition for land use, hunter-gatherer societies either adopted these practices or moved to other areas. In North and South America, for example, most large mammal species had gone extinct by the end of the Pleistocene, because of overexploitation by humans, although the overkill hypothesis is strongly contested.

As the number and size of agricultural societies increased, they expanded into lands traditionally used by hunter-gatherers. This process of agriculture-driven expansion led to the development of complex forms of government in agricultural centers such as the Fertile Crescent, Ancient India, Ancient China, Olmec, and Norte Chico. As a result of the now near-universal human reliance upon agriculture, the few contemporary hunter-gatherer cultures usually live in areas seen as undesirable for agricultural use.

Use of Fire

The earliest people feared fire like wild animals. They ran away from forest fire caused by lightning in great fear. The fiery lava flowing from erupting volcano was even more frightening. However, they noticed that fire could be useful. It warmed them in cold weather and defended them from wild animals. Obtaining fire from forest fire or volcano eruption, they started campfires day and night adding wood all the time. If people moved from one place to another they would carry a smoldering log with them. The wild predators did not dare to attack the people sitting around the brightly burning campfire at night. They also found that meat/plants cooked on fire tasted better than raw meat and plants. While cutting wood, especially bamboo in dry summers, people noticed that if they rubbed one piece of dry wood (bamboo) against another for a long time then it would begin to smolder. In this way man learned to obtain fire for himself. Thus campfires no longer depended on forest fire.

The Beginning of the Use of Metals

The time when the principal implements of labor were made of stone was called the "Stone Age". This age ended with the appearance of copper implements among people and the age of metal began. In some countries copper working began about 7000 years ago, in others it began considerably late.

Some tribes lived in places with copper deposits. Pieces of copper in the stone hearth were melted in fire. On cooling, the pieces assumed different shapes. People noticed this property of copper and began to make things out of it. For this, a mold of the needed form was made in clay or soft stone and the smelted copper was poured into it. As it cooled, the copper took the form of the mold. Axes, knives, sickles, and a number of tools required for different purposes were cast out of copper.

The other metal discovered at this time was tin. People also made implements by smelting copper and tin together, which resulted in the formation of an alloy called bronze. The bronze was a harder metal than copper.

The people then learned to make iron (Rigveda mentions iron c. 8000 BC). Ovens were made with stones or clay and charcoal and iron ore were put inside. Then the charcoal was lit and air pumped in by means of bellows for the charcoal to burn better. Lumps of iron were formed from the ore as a result of burning hard instruments and weapons were made from the lumps. Iron ore is more frequently encountered in nature than copper and tin. That is why iron tools were much more widespread than copper and bronze implements.

Iron plowshares could be used to cultivate not only soft soils of the river valley but also the firm soil of the steppe. Iron spades and hoes could be used for digging canals in the stony ground of the foothills and thus the people irrigated fields with water from rivers and streams originating in hills and mountains. Agriculture began to spread rapidly in the steppes and foothills. By means of iron implements the land tillers obtained more produce than that obtained by Stone Age implements.

Questions

1. Time span (years) of *Kaliyuga* are:
   (i) 232,000 (ii) 432,000 (iii) 632,000 (iv) 864,000
2. According to *Kala-Chakra*, already how many years of the present *Kaliyuga* have passed (assuming current year to be 2009)?
   (i) 5,000 (ii) 4,600 (iii) 5,110 (iv) 5,101
3. The period of unprecedented development of nascent agricultural practices is called:
   (i) Paleolithic (ii) Mesolithic (iii) Neolithic (iv) Monolithic
4. The first implement of labor developed by man was from:
   (i) Iron (ii) Copper (iii) Bronze (iv) Stone
5. About how many years ago, man became similar to present-day people?
   (i) 50,000 (ii) 40,000 (iii) 30,000 (iv) 20,000

CHAPTER 2

SINDHU-SARASWATI CIVILIZATION

India is separated from other countries by the world's highest mountains, the Himalayas, whose summits are always covered by snow. In ancient times the only route from India to other lands was through these mountain passes in the Northwest.

Nearly the whole Indian Peninsula is a tableland with deposits of copper and iron. Between the tableland and the Himalayas lie the plains. The "Sindhu River" flows through the western part of the plain and the "Ganga River" through the eastern part. Both the rivers have their origin in the Himalayas. They flood large areas when snow melts in the mountains.

Even winter is warm in India because it is protected from the cold northern winds by the Himalayas. Rains occur in the valleys. In ancient times the valleys were covered by marshland and impenetrable thick forests. It was inhabited by panthers, tigers, elephants, and other animals.

Origin of Aryans

It is rather a pity to admit that even several years after independence, we were not aware of our own true history and totally believed what foreign writers wrote. These writings were based on certain assumptions with no authentic evidences, and ignoring several facts. According to these historians, the Aryan tribes entered India from Central Asia in the 2nd millennium BC. The Aryans were nomads who wandered from one place to another with their belongings. Usually nomads were cattle breeders. When the cattle had eaten and tramped the grass at one place, they drove their herds to new places. The Aryans had cattle and chariots driven by horses. Moving through mountains with their herds, the Aryans gradually settled in a large part of India. They expelled the Dravidians, the original inhabitants, to southern peninsular region.

Recently with the intensive efforts of our archaeological and other scholars this "Aryan Invasion Theory" has been totally disapproved. This theory was actually put forward with certain devious aims and objectives in mind as given below:

- It served to divide the Indian culture into northern and southern (Dravidian) cultures.
- It gave the British an excuse for their conquest of India.
- It served to prove that Vedic culture was not original but derived from middle-eastern culture.
- It served to show that the science of India has Greek basis and there was nothing original.

Based on the "Aryan Invasion Theory", the writers discredited not only the Vedas and Puranas but also all the kings and kingdoms before Buddha including Rama and Krishna by saying that there is no historical basis of their existence. Ramayana and Mahabharata were considered as local tales exaggerated by poets. In short, most of the Hindu traditions and almost all the ancient literature were discredited.

This served as social, political, and economical tools for domination, proving the superiority of the Western culture and religion. It made the Hindus feel that there was nothing in their culture to be proud of. It also made them feel that the main line of civilization was developed first in the Middle East and then in Europe. The culture of India was peripheral and secondary to the development of world culture.

Although this approach was rejected by Indian Vedic scholars like Dayanand Saraswati, Bal Gangadhar Tilak, and Aurobindo, most Indians passively accepted it. Unfortunately Indian universities used and are perpetuating the Western history and the Western Vedic translations that denigrate Indian culture.

Why the Aryan Invasion Theory is not Acceptable

As described earlier the followers of "Aryan Invasion Theory" believe that Aryans were nomads and entered India from Central Asia with their horse-drawn chariots and iron weapons in the 2nd millennium BC. It was pointed out that no horses and chariots were discovered in Sindhu Valley site.

The first point that comes to mind is: Can a wide range of Himalayan Mountains be crossed by chariots? Every sensible person can understand that chariots are totally unsuitable for crossing the mountains and deserts. Their use is mainly for flat lands. Hence, the idea of Aryan migration from Central Asia through Himalayan Mountains is totally speculative.

The second point that no horses and chariots were found in Sindhu Valley site was incorrect. The excavations helped discover existence of horses not only in Sindhu Valley but also in the pre-Sindhu sites. The use of horses has been proven for the whole range of ancient Indian history. Evidence of wheel and Sindhu seal, showing a spiked wheel as used in chariots, has been found suggesting the use of chariots in India. Hence the theory seems to be a speculative vision of those persons who do not have in-depth knowledge of the event.

The third point is that there is no historical record of Indian culture before Buddha. Non- availability of historical records does not mean that Aryans did not know writing history. The literature on science, art, culture, astronomy, philosophy, and religion was very rich in ancient India. Unfortunately the invaders from West Asia in the medieval period destroyed most of the ancient literature. At some places the whole libraries were burned by them. The same trend continued when the British ruled India. The people of India being more religious tried their best to save the religious literature. But the ancient literature along with historical records vanished. The British took away some of the literature with them. A classic example is the presence of the original script of "Vrikshayurveda" in the Bodleian Library, Oxford, UK. Vrikshayurveda was written by Surapala about 1000 years ago. This is an ancient Sanskrit text on the science of plant life, which was a mere name until a few years ago. The name of the text as well as its author were preserved only by tradition because the original text was not available in our country.

With the efforts of Dr YL Nene, Chairman, Asian Agri-History Foundation, a photocopy of this Sanskrit manuscript was procured and was translated into English by Dr Nalini Sadhale, Retd.

Professor and Head of Sanskrit Department, Osmania University, Hyderabad. The ancient Indian literature and records are still present in foreign libraries, which are not easily available. This is enough to prove that the Indian ancient literature and historical records were destroyed and some of them taken away from the country.

The fourth point is that the Vedas, according to Max Müller, were composed during 1200–1500 BC and the Aryans or nomads entered India in the 2nd millennium BC. It is incomprehensible that nomads could develop the Vedic language 'Sanskrit', which is a complete and perfect language from grammatical point of view. It is unbelievable that the verses of hymns of Vedas which are composed in a particular *chhanda* and recited in a particular *swara* could be developed in such a short span of time, and that too by nomads. The recent archaeological investigations have proved beyond doubt that Aryans were the original inhabitants of India and theory of 'Aryan Invasion' is a pure concoction.

Hindu

In Rigveda the word 'Sindhu' was used for a natural ocean frontier or a large river. This word also connotes geographical area. With time, sound 's' was changed to 'h' and the word 'Sindhu' became 'Hindu'. Thus the word 'Sindhu' and 'Hindu' are synonymous geographical entities. The early use of the term 'Hindu' was thus not for any religious faith but for the people of the nation – the nation of 'Bharat'. According to some scholars some people moved westwards from Bharat to Indian-borders where the sound 's' was changed to 'h'.

Vedas

Vedas are the oldest literature in the world. Vedas include four compilations:

1. Rigveda (includes hymns)
2. Yajurveda (includes hymns and rituals)
3. Samaveda (includes re-composition of Rigveda for singing)
4. Atharvaveda (includes charm, i.e., magic power, against spirits and diseases)

Vedas are full of scientific knowledge and compilation of studies made by sages for innumerable years after collecting data. The Vedic literature recalls a high level of civilization which was present much earlier than Greek and other civilizations of the world. The famous French philosopher Voltaire said, "Vedas are the most precious gift for which the West has ever been indebted to the East." When Swami Vivekananda visited USA in 1901, he spoke on Vedas and Vedanta and acquainted the Americans with physical, chemical, and other active properties of material substances in Vedas. Rigveda is the oldest book of Aryans. According to Max Müller, the age of Rigveda is 1500–1200 BC. On the basis of researches now it has been established that the age of Rigveda is about 10,000 years. Rigveda has now been established to be the storehouse of knowledge including agriculture. During Vedic period the main occupation of the people was agriculture and the cultivated land was called "*Urvara*". Bullocks were used to plow the land. The land belonged to the community. There were channels for irrigation. People

had knowledge of the practices of crop production. They were aware of seed, sowing, harvesting, and threshing as evident by the following verse:

"O friend Rutwijas! Tie bullock to the plough, join yokes, sow the seed, let the food produced be sufficient and let the sickle fall on the ripe crop." (Mandal 10; Sukta 101; Verse 3).

Til (sesame), *dhan* (rice), *masoor* (lentil), and *urd* (black gram) were grown in abundance and these were also used during religious ceremonies.

The Aryan land was called "*Saptasindhava*", which means the land of seven rivers. These rivers were:

1. Sutudri (Sutlej)
2. Vipas (Beas)
3. Parushni (Ravi)
4. Asikni (Chenab)
5. Vitasta (Jhelum)
6. Sindhu (Indus)
7. Saraswati (which disappeared long ago)

Discovery of Saraswati River

Harappan civilization that developed on the bank of Sindhu (Indus) river was considered as the oldest civilization in India. Recently, archaeology researchers provided evidence of the presence of "Saraswati" river as mentioned in Rigveda. This river flowed from Hardikun glacier of Himalayas to Arabian Sea through Kutch. Sutlej and Yamuna were the tributaries of Saraswati. In Vedic period this river had been a mighty river which sustained supply of water for domestic and irrigation purposes and as such a very strong culture could be developed here.

Tectonic disturbances occurred in Kalibangan about 2500 BC. The C^{14} dating indicated that the time of desiccation of river Saraswati corresponds with these tectonic disturbances. The recent earthquake in 2001 AD in Kutch region measuring 7.6 to 8.1 on Richter scale reminds the tectonic disturbances that occurred in this region. As a result of these tectonic events, the Sutlej and Yamuna rivers, which were the tributaries of Saraswati, drifted their courses. Sutlej joined the Sindhu system and became a tributary of Sindhu river, whereas Yamuna became a tributary of the Ganga river. It appears that when these tributaries shifted, the Saraswati river dried up and the people began to move in search of water, and thus they settled on the banks of Sindhu river and a strong culture developed there.

Harappan Chalcolithic culture existed in the regions of Punjab, Haryana, Jammu, Uttar Pradesh, Rajasthan, Gujarat, and Madhya Pradesh. It also existed in Sindhu and western Punjab (now in Pakistan). Excavations carried out at Harappa by Dayanand Sahni and at Mohenjo-daro by RD Banerjee in 1921 revealed that the Chalcolithic culture existed here about 4300 years ago. Harappa is located 160 km from Lahore and Mohenjo-daro is located 320 km from Karachi.

Of the 2600 cities of Harappan civilization known in India and Pakistan, nearly 80 percent of those are located on the vast plain between Sindhu (Indus) and Ganga (Ganges) rivers. It is the region of Saraswati river that was discovered recently. These are major settlements which are larger than the settlements of Harappa and Mohenjo-daro. These settlements are dated 4000 to 3000 BC during the late Harappan culture. The settlements comprised:

1. Lakhmirwala – Bhatinda, 225 ha
2. Rakhigari – Hisar, 224 ha
3. Gurmikalan – Bhatinda, 144 ha
4. Hasanpur – Bhatinda, 100 ha
5. Gunweriwala – Bhawalpur, about 80 ha
6. Kotada – Jamnagar, 72 ha
7. Nagoor – Sukkur, 50 ha

As described earlier, the Aryans began to move in search of water when the river Saraswati dried up, and a strong culture developed on the bank of Sindhu river. Thus the Indian civilization was a continuous and indigenously evolved culture principally on the bank of Saraswati river and then on the banks of river Sindhu (Indus) and its tributaries. Therefore, the Harappan civilization has been renamed as "Sindhu-Saraswati" civilization (8000 to 1400 BC).

Phases of Sindhu-Saraswati Civilization

Four phases of Sindhu-Saraswati civilization are recognized:

1. Saraswati (8000 to 3300 BC)
2. Early Harappan (3300 to 2800 BC)
3. Mature Harappan (2800 to 1900 BC)
4. Late Harappan (1900 to 1400 BC)

The sites of Hulas and Jodhpura (Ganeshwar culture) are of early phase. Kalibangan, Surkota, Lothal, and Rajodi are sites of mature phase. Late phase is represented by Daimabad.

The available archaeological evidences suggest that there was westward movement of people of Kashmir and Baluchistan during early and mature phase of Sindhu-Saraswati civilization. High agricultural prosperity was witnessed during mature phase when crop rotation, i.e., cultivation of indigenous crops in summer/rainy season and Southwest Asian crops in winter season, was practiced. Drying of Saraswati river forced the people to move. Such movement resulted in the establishment of culture in the plains of Ganga (Uttar Pradesh and Bihar) and also in the South (Raichur and Bellary). A number of states or *Mahajanapadas*, viz., Magadha, Kosala, Avanti, and Panchala appeared in North India.

Almost continuous devastating wars occurred between the states for land, slaves, and other booty. In these wars some states perished and others rose to supremacy. Around 600 BC, the

Magadha state began to grow strong. Chandragupta Maurya overthrew the Nanda dynasty in 321 BC. His chief advisor was Chanakya, also known as Kautilya, who wrote Artha-sastra. The Mauryan Empire had Superintendents of agriculture, forestry, pasture lands, cows, horses, and elephants. The state reached its peak under the third king from Maurya family, Ashoka in 300 BC. However, the vast Maurya kingdom could not be stable and began to break at the end of Ashoka's reign, and was divided into several independent states.

The period around 600 BC was marked by both Buddhism and Jainism. After Ashoka, Satvahanas ruled Andhra, Karnataka, Vidharba, Malwa, and West Rajasthan. A number of other kings ruled in different states of India till Arabs conquered Sindh during 711–712 AD, and thus began the Islamic period of Indian History.

Agriculture and Art

The communities reclaimed the lands for crops in the Ganges Valley step by step. They dug canals and plowed the land. With abundant moisture and warmth, the fertile soil yielded good harvests. The iron plowshare and spades were used to till the hard soils as well. Oxen were used in plowing. Agriculture began to spread to India's tableland too.

The Indians grew grains (e.g., rice), cotton, sugarcane, etc. Cotton was used to make fine fabric. The dresses made out of this strong and fine fabric were so thin that a whole dress could easily pass through a small ring. The Indians had cattle and horses. For the first time, the wild chicken was domesticated in India. The Indians tamed elephants forcing this huge animal to serve people. The elephants were used to uproot the trees, carry people and loads. The elephants were also trained to take part in battle. Nandas maintained 6000 elephants and Chandragupta Maurya had 9000 elephants for warfare.

Indian cities began to grow rapidly from the middle of 1st millennium BC. The largest city was Pataliputra (now Patna) on the bank of Ganga river. Writings emerged in India between 3000 and 2000 BC. The people used to write on date palm leaves, cutting them into rectangles. The writing was forgotten due to the destruction of ancient cities.

The new writings then emerged in 1000 BC. The Indians were pioneers in stone building but following the destruction and abandonment of their ancient cities, stone building ceased for a long time in the country, which was resumed only after large states were formed in India particularly in the reign of Ashoka. Roads were made which led from Pataliputra to India's other cities. Geometrical shape of buildings and city blocks and exact lines of canals showed that Indians knew geometry quite well. The tall columns built by Ashoka are monuments of the Indian kingdom. Every column was made on a huge rock. Four stone lions stand on one of them. They look in four directions as if guarding the state boundaries. Today this serves as the state emblem of the Republic of India.

The Indians introduced zero into mathematics. This enabled them to elaborate a simple and convenient way of counting by means of ten number symbols. Today almost the whole world

uses this system. Europeans call the numbers Arabic because they learned them from Arabs; the Arabs called them Indian because they learned them from Indians.

Relations With Other Countries

India's relations with other countries were weakened after the abandonment of cities in Sindhu Valley. These relations expanded once again with the development of agriculture, livestock breeding, education, and craft with the rise of large states in India. Ships sailed from seaports to Mesopotamia and Egypt and also to Southeast Asia, Sri Lanka, and China. Caravans traveled through the mountains pass to Central Asia and shores of the Mediterranean Sea. Fine fabrics, precious stones, ivory, and other luxury items from India were highly valued in Europe. In addition to merchants, India was visited by embassies, scholars, and travelers of different countries, and sent its own convoys to these countries.

There were particularly close relations between India and the countries of Southeast Asia in ancient times. Indians not only traded with the inhabitants of Indo-China and Indonesia but also settled in these countries. Educated people of India served at the courts of local kings in these countries and occupied high posts. Relations with India greatly contributed to the development of culture, writing, the art, and scientific knowledge in the countries of Southeast Asia.

Creating their own culture, the Indians also borrowed a great deal from other countries in ancient times. The Indian people thus made major contributions to the culture of the ancient world by passing to neighboring and distant lands much of what they created.

Recently, in 2001 AD, a submerged city has been discovered in the Gulf of Cambay (Gulf of Khambhat) in Gujarat. The Cambay site is in the ancient delta of the dry Saraswati river. The archaeological excavation in Lothal and Dholavira (Dholera) has revealed that the city existed around 7500 BC. The discovery also revealed that the civilization which existed here may be much older than the Harappa civilization.

The foreign historians did not recognize the empires/states before Buddha for want of historical records. Perhaps they overlooked "Indika", a book written by Magesthenes in 400 BC in which he clearly mentioned that Indians (Hindus) had a record of 153 kings pushing back Indian history by 6400 years, i.e., 6800 BC. The period of the city discovered is tentatively determined as 7500 BC which seems to be very close to this calculated period.

The discovery supports the view that Lord Krishna, when he left Mathura, made Dwaraka (Gujarat) his capital which ultimately sunk in the sea. It may be due to "submergence" process of tectonic disturbances. The same case may be with "Rama Setu" which was built by Rama to cross the sea while going to Sri Lanka.

Recently two projects were started by the Archaeological Survey of India, one on "Ramayana" and the other on "Mahabharata". The initial results were encouraging but due to reasons unknown, no further investigations could be carried out. It is not surprising that the efforts of the Government

of India and intensified archaeological researches by scholars at the sites mentioned would reveal the existence of these two world's advanced and oldest periods in the development of human civilization.

Questions

1. Which of these people came to India from outside?
   (i) Aryans (ii) Dravidians (iii) Persians (iv) Arabs
2. Which of the following Vedas is the last one to be compiled?
   (i) Rigveda (ii) Atharvaveda (iii) Samaveda (iv) Yajurveda
3. Max Müller wrongly fixed the date of Rigveda. Which one?
   (i) 1500 BC (ii) 2500 BC (iii) 8000 BC (iv) 5000 BC
4. Vedic Aryans were primarily:
   (i) Hunters (ii) Gatherers (iii) Migratory tribes (iv) Farmers
5. Which of the following were *Mahajanapadas*?
   (i) Magadha (ii) Kosala (iii) Mathura (iv) Pataliputra

CHAPTER 3

BEGINNING AND DEVELOPMENT OF AGRICULTURE

The settlements of Sindhu plains and Baluchistan hills revealed that agriculture began here about 8000 BC with barley and wheat cultivation along with goat and sheep herding. Such settlements expanded across Sindhu system from about 3500 BC and eventually to the plains. Thereafter, a wide agricultural settlement to the Southeast seems to have arisen. Subsequent development in India relied on its secure agriculture base which produced Harappan culture. This culture assumed dominance and expanded agriculture.

Baluchistan and Pakistan

Mehrgarh

The earliest evidence so far of settled agriculture comes from Mehrgarh (now in Pakistan) situated in North Kachi plain at the foot of Bolan Pass in the zone of transition between the Iranian Plateau and Sindhu basin about 6500 BC. Thousands of impressions of crops in mud bricks were identified which show that in early stage naked six-rowed barley was mostly used. Other cereals, viz., hulled two-rowed barley and wheat were also cultivated to varying extent. The naked barley, a local domesticate must have been the main staple food of the people. Date palm provided additional food.

Apparently between 5500 and 4700 BC, the processes of plant and animal domestication were completed. The changes were gradually brought about through the following initiatives:

- Incorporating high-yielding bread, club, and dwarf wheats in cropping pattern.
- Replacing low-yielding two-rowed barley with high-yielding six-rowed naked and hulled barley.
- Domesticating and managing sheep, goat, and cattle.

In the early Chalcolithic phase, i.e., 4700–4300 BC, wheat (bread, club, and dwarf), hulled and naked barley were cultivated. Fruits of jujube, *Prunus*, and cotton were added. The period between 4300 and 3500 BC was marked by manufacture of wheel-made pottery. The practice of cultivating high-yielding hexaploid wheat and barley continued.

During the period 3500–3200 BC, barley continued to be an important food but there was a dramatic increase in wheat cultivation. Through intensive land use and cultivation of high-yielding hexaploid wheat, the agricultural production was intensified. The cultivation of oats and grapes was also taken up in this phase.

The period between 3200 and 2500 BC is marked by the cultivation of a number of *rabi* (postrainy season) crops in Mehrgarh. The following crops were taken:

- *Triticum aestivum* (bread wheat)
- *Triticum compactum* (club wheat)

- *Triticum sphaerococcum* (dwarf wheat)
- *Hordeum vulgare* (six-rowed hulled barley)
- *Pisum sativum* (field pea)
- *Lens culinaris* (lentil)
- *Cicer arientinum* (chickpea)
- *Linum usitatissimum* (linseed)
- *Vitis* sp. (grape)
- *Gossypium* sp. (cotton)
- *Ziziphus* sp. (jujube)
- *Phoenix sylvestris* (date)

Wood of juniper from highland was used for fuel. Mehrgarh was abandoned in 2500 BC.

Balakot

During 4000 to 2900 BC, several peasant communities flourished in the Quetta and Zhob Valley of Baluchistan. These communities did not cultivate specific crops grown at Mehrgarh. People cultivated specific crops depending on their availability and adaptation to local environments. They also cultivated crops not grown at Mehrgarh. Balakot, in Southern Baluchistan is a small site located near the Arabian Sea coast about 90 km Northwest of Karachi. At Balakot only six-rowed barley, vetch (*Vicia* sp.), jujube, and melon or gourds were taken.

Saraikhola and Swat

In Baluchistan, Neolithic settlements (3100–2900 BC) were found at Saraikhola and Swat but in other areas like Loebanr, Chalcolithic settlements (2300–1500 BC) were identified. Here the farmers cultivated the following crops in winter:

- *Hordeum vulgare* (six-rowed hulled barley)
- *Triticum* sp. (wheat)
- *Lens culinaris* (lentil)
- *Pisum sativum* (field pea)

In summer, rice was taken. The presence of West Asian legumes and Indian rice indicates contacts of people with western and eastern culture, respectively. In crop rotation, rice cultivation was followed by winter-grown legumes and cereals. This practice made the farmer to work year round and also provided surplus food production.

Harappa and Mohenjo-daro

During 3200–2500 BC the farmers of Harappa and Mohenjo-daro (now in Pakistan) cultivated wheat and barley in winter. Sesame was cultivated in rainy season, whereas mustard was cultivated at Chanu-daro in winter. For the sake of convenience the crops grown at Harappa are grouped in three-tier system based on the importance of the food crops.

1. Tier I
- *Triticum* sp. (wheat)
- *Hordeum vulgare* (barley)

2. Tier II
- *Eleusine coracana* (finger millet, *ragi*)
- *Pisum sativum* (field pea)
- *Cicer arietinum* (chickpea)
- *Lathyrus sativus* (grass pea)
- *Lens culinaris* (lentil)
- *Vigna radiata* (mung bean, green gram)
- *Linum usitatissimum* (linseed)
- *Brassica* sp. (mustard)
- *Gossypium* sp. (cotton)

3. Tier III
- *Oryza sativa* (rice)

Rice was a minor crop at Harappa because the cultivated crop was not well suited to that environment. Even today it is not a prominent crop.

In addition evidences suggest that the people of Harappa and Mohenjo-daro were familiar with some fruits like *Punica granatum* (pomegranate), *Cocos nucifera* (coconut), *Cucumis* sp. (melon), and *Ziziphus* sp. (jujube).

The Harappans used scented wood of *Cedrus deodara* (deodar) and *Dalbergia latifolia* (rose-wood) for making coffins and jujube wood for making wooden mortars for pounding grains.

Rajasthan

Sambhar, Lunkaransar, and Didwana

The earliest evidences of full-time plant and animal domestication on the Indian subcontinent are found in Sambhar, Lunkaransar, and Didwana in the vicinity of saline Sambhar lakes of Northern Rajasthan. The presence of cereal pollen, mixed datable charcoal, was considered as evidence of forest clearing and planting of grain seeds (c. 7000 BC). The periodic fires in Rajasthan's savannahs practiced for inducing fresh growth of grasses for their domesticated animals shows the domestication of animals as early as 8000 BC.

Kalibangan

The people of Kalibangan, Rajasthan began to include pastoralism in their hunting-foraging strategies by capturing certain wild animal species trapped in marshy tracts of Ghaggar river, but by 3000 BC they began to cultivate wild plant species (not identified) as fodder along with some crops that originated in Southwest like field pea and chickpea. Hulled and naked barleys were also cultivated in Kalibangan.

Bagor

At Bagor no domesticated species of plants have been found, but there were domesticated species of sheep, goat, buffalo, humped cattle, and pig along with species of chital, sambar, hare, and fox as early as 5000 BC.

Ahar (Udaipur) and Noh

At Ahar, one season farming was practiced during 2000–1400 BC by cultivating rice and sorghum (*Sorghum bicolor*), which provided grains for humans and green fodder/straw for animals, respectively. The farmers also cultivated sorghum, which provided grains for humans and fodder for animals. During 1100–900 BC apart from rice, *Dolichos uniflorus* (horsegram) and *Vigna mungo* (black gram) were cultivated at Noh in Rajasthan.

All the plant species identified from several sites of Rajasthan during 2200–800 BC put together are given below:

- *Oryza sativa* (cultivated rice)
- *Hordeum vulgare* (six-rowed hulled barley)
- *Sorghum bicolor* (sorghum)
- *Cicer arietinum* (chickpea)
- *Pisum sativum* (field pea)

Gujarat

Plant remains at Rajodi (2500–1400 BC) revealed that a number of crops were cultivated in this region. In addition about 50 wild species, some of which provided edible plant parts were also identified. Three phases or tiers of cropping pattern were recognized at Rajodi.

1. Phase I
- *Eleusine coracana* (finger millet; *ragi*)
- *Panicum miliaceum* (slender millet, proso millet)
- *Setaria italica* (foxtail millet, Italian millet)

2. Phase II
- *Pisum sativum* (field pea)
- *Lens culinaris* (lentil)
- *Dolichos uniflorus* (horsegram; *kulthi*, *kulatha*)
- *Vigna* sp.
- *Linum usitatissimum* (linseed)
- *Ziziphus mauritiana* (jujube)

3. Phase III
- *Hordeum vulgare* (barley)
- *Brassica campestris* (mustard)
- *Cucumis* spp. (melons)

At Lothal, husk and spikelet impressions of rice were found during 2300 BC. Other plant remains found in Gujarat were of pearl millet (*Pennisetum glaucum*) from Rangpur, finger millet from Shikarpur (Rann of Kutch), and Italian millet from Surkotada. Carbonized seeds from Surkotada were of *Setaria italica* and leafy vegetables like *Chenopodium album* and amaranths.

The subsistence economy provided surplus food when barley, sorghum, finger millet, and pearl millet began to supplement or even replace several species of indigenous millets under rainfed conditions during 2000–1700 BC.

Madhya Pradesh

The inhabitants of Kayatha village of Madhya Pradesh used to cultivate horsegram in rainy season during 2000–1000 BC. Then diffusion of wheat to this region took place and the farmers started to cultivate wheat in winter season. Later wheat diffused to other areas of Madhya Pradesh.

At Dangwada (1200–1400 BC) the following crops were cultivated:

- *Oryza sativa* (cultivated rice)
- *Vigna mungo* (black gram)
- *Vigna radiata* (mung bean, green gram)
- *Triticum aestivum* (bread wheat)
- *Triticum compactum* (club wheat)
- *Lens culinaris* (lentil)

During 1700–1400 BC, the farmers of Navdatoli-Maheshwar cultivated the following crops:

- *Triticum aestivum* (bread wheat)
- *Triticum compactum* (club wheat)
- *Oryza sativa* (cultivated rice)
- *Pisum sativum* (field pea)
- *Lens culinaris* (lentil)
- *Lathyrus sativus* (grass pea)
- *Vigna mungo* (black gram)
- *Vigna radiata* (mung bean, green gram)
- *Linum usitatissimum* (linseed)

Punjab

In Early Harappan phase (3300–2800 BC) of Sindhu-Saraswati civilization, the following crops were cultivated at Rohira, Sangrur district of Punjab:

- *Hordeum vulgare* (six-rowed hulled barley)
- *Triticum sphaerococcum* (dwarf wheat)
- *Triticum dicoccum* (emmer wheat)
- *Sorghum* sp.
- *Dolichos uniflorus* (horsegram)

In addition, plant remains of grape and *mehandi* (*Lawsonia inermis*; henna) were also identified from Rohira. Evidences show that farmers of this region cultivated naked barley and fenugreek (*methi*) during 2800–1900 BC.

Similarly at Mahorana, Sangrur district of Punjab, the evidences from wood charcoal of plant remains revealed the cultivation of the following crops during Early Harappan phase (3300–2800 BC) of Sindhu-Saraswati civilization:

- *Hordeum vulgare* (six-rowed hulled barley)
- *Triticum sphaerococcum* (dwarf wheat)
- *Triticum dicoccum* (emmer wheat)
- *Lens culinaris* (lentil)

Grapes and *Lablab purpureus* (lablab bean, hyacinth bean – a vegetable) were also identified in this region.

During Mature Harappan phase (2800–1900 BC) of Sindhu-Saraswati civilization due to diffusion, a large number of crops were identified at Sanghol:

- *Triticum sphaerococcum* (dwarf wheat)
- *Triticum dicoccum* (emmer wheat)
- *Hordeum vulgare* (six-rowed hulled barley)
- *Sorghum* sp.
- *Setaria italica* (foxtail millet, Italian millet)
- *Pisum sativum* (field pea)
- *Lens culinaris* (lentil)
- *Cicer arietinum* (chickpea)
- *Dolichos uniflorus* (horsegram)

In addition, the plant remains of *Emblica officinalis* (*amla*), grape, and poppy were also identified from Sanghol.

In Haryana, *Vigna mungo* (black gram) was reported from Daulatpur and Kurukshetra districts and grains were identified from Hisar but the period is not known.

Uttar Pradesh

Evidences revealed that wild rice was eaten by the people of Chopani Mando of Uttar Pradesh in the advanced Mesolithic or pre-Neolithic period (c. 8000 BC). The use of *vrihi* (the oldest Sanskrit name of rice) has been mentioned in Krishna Yajurveda which also indicates that the Vedic people were using rice around 7000 BC in India.

Later during 6000 BC the use of rice continued at Koldihwa and Mahagarh as evidenced by the identification of rice grain remains from these areas. This can be considered as the earliest cultivation of rice in South Asia. After this there is a big gap in the archaeobotanical records of cultivated plants till the 3rd millennium BC.

Plant remains identified from Hulas, Atranjikhera, Sringaverapura, and Lal Quila (Bulandsahar) in Uttar Pradesh during 2000–1200 BC showed that the people not only cultivated the indigenous crops but also crops diffused from other countries. The following crops were cultivated:

- *Oryza sativa* (cultivated rice)
- *Oryza rufipogon* (wild perennial rice)
- *Dolichos uniiflorus* (horsegram)
- *Vigna radiata* (mung bean, green gram)
- *Vigna mungo* (black gram)
- *Triticum aestivum* (bread wheat)
- *Triticum compactum* (club wheat)
- *Triticum sphaerococcum* (dwarf wheat)
- *Hordeum vulgare* (barley)
- *Avena sativa* (oat)
- *Pisum sativum* (field pea)
- *Lens culinaris* (lentil)
- *Cicer arietinum* (chickpea)
- *Sorghum bicolor* (sorghum)
- *Eleusine coracana* (finger millet; *ragi*)
- *Vigna unguiculata* (cowpea)
- *Ricinus communis* (castor)
- *Gossypium arboreum* (cotton)

Maharashtra

Remains of dwarf wheat and barley identified from Daimabad during 2000–1700 BC revealed that farmers practiced rainfed agriculture in winter but the crops cultivated in rainy season are not known. During 1700–1450 BC, plant remains from Inamgaon and Daimadad associated with Malwa culture were identified which indicated that the following crops were cultivated by the farmers of this region in winter and rainy season:

- *Triticum compactum* (club wheat)
- *Triticum sphaerococcum* (dwarf wheat)
- *Hordeum vulgare* (barley)
- *Pisum sativum* (field pea)
- *Lens culinaris* (lentil)
- *Eleusine coracana* (finger millet; *ragi*)
- *Vigna unguiculata* (cowpea)
- *Vigna mungo* (black gram)
- *Lablab purpureus* (lablab bean, hyacinth bean)

Later during 1400–800 BC, diffusion took place and a number of crops were cultivated. The farmer used cereals, legumes, and oilseeds for adopting cropping patterns suited to dryland and

wetland conditions. The low-yielding crops were replaced by high-yielding ones. Such changes produced enough surplus food.

South India

Plant remains of Neolithic Age from South India are meager. Wild finger millet (*Eleusine indica*) and cultivated finger millet (*Eleusine coracana*) were identified from Hallur (1800 BC) and horsegram (*Dolichos uniflorus*) from Tekkalakota in Karnataka and Paiyampalli from Tamil Nadu. Finger millet, an African domesticate, was added either through direct contact with Africa, via sea or it was introduced with Chalcolithic culture of Maharashtra.

During 200 BC, the main profession of the people of Tamil Nadu had been agriculture. This region extended from Kanyakumari in South to Tirupati in North and part of Kerala and Karnataka in the West. The people made advancement in agricultural operations and plant protection. The following main crops were taken by the farmers:

- *Oryza sativa* (cultivated rice)
- *Eleusine coracana* (finger millet; *ragi*)
- *Saccharum officinarum* (sugarcane)
- *Elettaria cardamomum* (cardamom)
- *Gossypium* sp. (cotton)
- *Cocos nucifera* (coconut)
- *Musa paradisiaca* (banana)

Farmers were aware that rice could be grown only on wetlands with assured irrigation. Banana and sugarcane were ratooned. They practiced crop rotation by raising black gram after rice. The people used buffaloes for plowing.

Bihar

During 2000–1200 BC, the farmers of Chirand and Senuwar started practicing agriculture by cultivating rice in rainy season. But, when they came in contact with other cultures, they started growing crops in winter also. The following crops were initially cultivated by the farmers:

- *Triticum sphaerococcum* (dwarf wheat)
- *Hordeum vulgare* (six-rowed hulled barley)
- *Lens culinaris* (lentil)
- *Pisum sativum* (field pea)
- *Lathyrus sativus* (grass pea)

A system of rotation of crops emerged that engaged the farmers round the year. When farmers who were taking *Panicum* sp. under rainfed conditions observed that the diffused crop sorghum (*Sorghum bicolor*) and finger millet (*Eleusine coracana*) yielded more than *Panicum*, they started to take these crops.

During 1800–1200 BC, diffusion of crops increased further and these farmers started cultivation of *Triticum aestivum* (bread wheat) and *Cicer arietinum* (chickpea) in addition to the crops already taken in winter. *Vigna radiata* (mung bean, green gram) and *Dolichos uniflorus* (horsegram) were added in rainy season crops.

During 1100–800 BC, the cropping system was further intensified by incorporating *Sesamum indicum* (sesame) for cultivation in rainy season; and *Linum usitatissimum* (linseed) and *Carthamus tinctorius* (safflower) for cultivation in winter.

Thus in Bihar, a subsistence system based on single system cultivation changed into an increasingly more productive farming system by gradually incorporating several additional cereals, legumes, and oilseed crops, whether indigenous or exotic. The farmers accepted those crops which were found good yielders in the prevailing agroclimatic conditions – dryland or wetland, and rejected the poor yielders.

Religion and Literature

The period between 800 BC and the beginning of Christian Era is marked by revolutionary development in Indian agriculture. During 600 BC Buddhism and Jainism came into existence; the followers worshiped trees and developed sacred small orchards. These religions were very much associated with vegetation. *Ficus religiosa* (pipal), *Ficus benghalensis* (banyan), *Shorea robusta* (sal), and *Mangifera indica* (mango) were considered most sacred trees. Expansion of agriculture during this period took place in Bihar and eastern Uttar Pradesh. Jains adopted trade and moneylending because they believed the agricultural operations caused violence. During Buddhist period Brahmins engaged themselves in agriculture.

The ancient agricultural technologies developed in India so far were transferred to the next generation by oral communication. The sage Parashara (c. 400 BC) wrote Krishi-Parashara, which is considered as the first written document on agriculture. Krishi-Parashara deals with each and every aspect of agriculture as well as implements used in agricultural operations. Much emphasis was given to seed collection and storage, sowing, weeding, irrigation, draining, water retention, and water harvesting. Not only this, Parashara also described the methods of prediction of rainfall and its measurement.

Kautilya or Chanakya was the chief advisor of Chandragupta Maurya who overthrew the Nanda dynasty. Kautilya wrote "Kautiliya Artha-sastra" (c. 300 BC). He also laid great emphasis on agriculture along with administration. He suggested appointments of Superintendents of agriculture to deal with plantation of bushes and trees, and made them responsible for all agricultural activities like collection of seed of all kinds of grains, fruits, flowers, vegetables, fiber crops, and their cultivation/ plantation. Similarly, Superintendents were appointed to look after forestry, pasture lands, and animals.

During 304–232 BC, Emperor Ashoka adopted state policy on arboriculture and horticulture, the first of its kind in the world. He encouraged the planting of mango, banana, grape vine, jack fruit, and date palm.

The documents of sage Parashara and Kautilya guided the people in practicing agriculture in ancient period. The food production increased which brought prosperity to the people. Emphasis on non-violence boosted cattle wealth and cow attained "sacred" status.

In the beginning of Christian Era, the Kushans from Central Asia conquered Kabul Valley areas, west of India and later advanced up to Mathura (Uttar Pradesh). In 78 AD Kanishka ascended the throne. His capital was Purushpur (now Peshawar). He ruled Kashmir, Punjab, Sind, Malwa, and plains of Ganga up to Patna. Taxila was the center for the development of iron technology. Iron was exported to West Asia. Cultivation of rice, *ragi*, sugarcane, cotton, and turmeric was common. Irrigation was developed and practiced widely. Other kings like Chandragupta I, Samudragupta, Chandragupta II, and Vikramaditya ruled India. In this period there was revival of art, literature, and science.

In this era, the agriculture in India continued to keep the production high. The protection of the crops was felt necessary and adequate attention was given to this aspect. A number of sages like Varahamihira (505–587 AD), Kashyapa (c. 800 AD), Surapala (c. 1000 AD), Sarangadhara (1283–1301 AD), and Chakrapani Mishra (1577 AD) contributed a lot to boost Indian agriculture.

Questions

1. In Western India, processes of plant and animal domestication were completed apparently during:
   (i) 3000 to 2000 BC (ii) 5500 to 3500 BC (iii) 5500 to 4700 BC (iv) 4700 to 3700 BC
2. Kalibangan, an archaelogical site is located at present in:
   (i) Sindh (ii) West Bengal (iii) Punjab (iv) Rajasthan
3. In Gujarat an important archaeological site that has been located is:
   (i) Ahar (ii) Dangwada (iii) Rojdi (iv) Navdatoli-Maheshwar
4. State policy on arboriculture and horticulture was adopted in ancient times in India by:
   (i) Kautilya (ii) Ashoka (iii) Kanishka (iv) Vikramaditya
5. Which of the following were considered sacred trees in post-Buddha period?
   (i) *Ficus religiosa* (ii) *Shorea robusta* (iii) *Butea monosperma* (iv) *Terminalia arjuna*

CHAPTER 4

ROLE OF WOMEN IN AGRICULTURE

Woman, the mother of human civilization, has been recognized as a symbol of patience, peace, politeness, progress, and power. Therefore, our ancient seers composed the verse:

"Yatranaryastu pujayante ramante tatra devata
Yatraytastun pujayante sarvastatrafal kriya."

This means that "God lives where women are worshiped; where women are not worshiped, all sorts of deeds are unsuccessful."

Another verse "*Janani janambhumishchya swagradapi gariasi*" means that "Mother and motherland are greater than paradise." This shows that a woman has a prestigious position in the social system of ancient India. The woman was recognized as Durga (the Goddess of power), Laxmi (the Goddess of wealth), Saraswati (the Goddess of knowledge), and Annapurna (the Goddess of food). No religious ceremony or ritual was considered complete without the participation of wife with her husband. In Ramayana, in the absence of Sita, a golden idol of Sita was made, seated by the side of Rama to complete an important ceremony.

Discovery of Agriculture

It may not be agreeable to men but it is a fact that the art of growing plants was first discovered by women. Actually farming originated from gathering. The women who gathered edible grains made a great discovery. They noticed that the grains, which inadvertently fell on the ground or were thrown away considering them unsuitable for food, emerged into new plants. Women then began to bury the grains in the ground and after that they also came to know that the plants grown from these grains bore similar kind of grains. By repeating the process they could get more grains at one place. This was the starting point of crop production and the end point of gathering activity of the ancient man.

Role of Women in Crop Production

Women participation in crop production varies widely across different ecological sub-zones, farming systems, castes, and class composition. The involvement of women in crop production also varies according to the type of crop grown. The involvement of women in agriculture is about 80 percent in India, which includes agricultural operations of their own farm or as agricultural laborers irrespective of the community they belong. Women are major food producers in terms of value, volume, and hours worked in agriculture and allied activities. The rural women are generally engaged in the following crop production activities: (i) Sowing; (ii) Weeding; (iii) Irrigation; (iv) Harvesting; and (v) Postharvest operations.

Sowing

Sowing is one of the most important farm operations. The time of sowing and the way in which it is done influence the germination of seeds, growth, and the plant population as a whole. Nearly 80 percent of the sowing operation is still done manually in which women's main task is dropping the seeds behind the country plow. Women have to walk 60 to 80 km to sow the seeds in one hectare of land.

Transplanting of paddy in wetlands is also a non-mechanized operation. It is the most tiresome and time-consuming operation in agriculture. The operation is mostly done by the rural women who transplant paddy while bending the body forward and moving backwards in the puddled fields.

Weeding

In order to ensure that the soil nutrients are properly utilized by the crop plants, weeding is the essential operation which is mostly performed by women. This manual operation is done with the help of *khurpi.*[1] The women work hard for several hours to remove the weeds from the field.

Irrigation

It had been the practice in Indian agriculture that men's job is to lift water from the wells and irrigating the fields is women's job. It is a common scene still prevailing in the unelectrified villages. Mechanization, no doubt, has given some relief to women by shifting a part of the job to men.

Harvesting

Harvesting in India is still done manually and 90 percent of area is harvested with the most common hand tool – the sickle. This operation too is done by rural women.

Postharvest operations

Rural women are equally involved in the following postharvest operations:

- Threshing of maize cobs and decortication of groundnut.
- Transportation and chaffing the fodder.
- Milling of pulses.
- Drying, grading, cleaning, and storage of grains.
- Grinding of grains for flour and pounding of rice.

Women also undertake some routine activities such as collection of firewood, preparation of cow dung cakes, collection of drinking water, cooking, child rearing, and animal care at household level.

Role of Women in Animal Husbandry

It has been observed that in certain cases the participation of rural women is more in animal husbandry than in food production. Participation of rural women is highest in providing feed and

1. A hand tool called *khurpi* consists of a sharp edged triangular or sickle-shaped blade. It has a small handle and the user has to sit on his/her heels and bend his/her back while weeding.

water to animals, care of animals during pregnancy, care of newborn calf, milking, and cleaning and bathing of animals. They are also involved in the processing of livestock products; for example, preparation of ghee (clarified butter). With the development of dairy industry, the women collect the milk for cooperative societies. There are some societies which are managed by women only who supply milk to different dairy units.

Role of Women in Silk Production

Indian women play an important role in silk production. About 50 percent women are involved in different activities of sericulture. In mulberry cultivation, women are involved in operations like planting, weeding, and leaf harvest. In silkworm rearing, mainly women are involved as it is an indoor activity and requires skill and delicacy. In rearing activity, women's role is dominant. In weaving, however, they have a supportive role.

Role of Women in Hill Areas

Most of the agricultural operations in the hills are carried out by women because men usually migrate to plains in search for work and are not available to participate in the agricultural operations. Women traverse large distances up and down the hills due to scattered landholdings. Majority of women spend at least 5 to 6 hours per day in the fields. The rest of the time is spent in fetching fuel, fodder, water, and household activities. This indicates that the image of women is first as farmer, then as householder, and lastly as mother to attend to her off-springs. For her leisure, she gets only a little time.

Apart from this women are also actively engaged in other activities to support their family economy. The majority of workers involved in the collection of non-timber forest produce are women. The fisherwomen play a significant role in general livelihood of fishermen family. The fishes collected by fishermen are transported, graded, and also sold in the local market by fisherwomen.

Women and Food Security

Food and its continuous availability were considered as primary concerns by Vedic Aryans which is clearly depicted in their prayers: "O Pusha! (i.e., Sun) Fill our houses with food grains and our stomachs with excellent food." Much emphasis was given on the proper utilization of food and on the restriction of food-wastage. Ayurveda recommends limited intake of food for good health. According to Charaka, "One must eat only as much as one can easily digest. Only such food gives strength, complexion, happiness, and long life." Food should never be wasted and only as much food as one needs should be served. Obviously restraint on consumption was a method of conservation of food and ensuring the food security.

Eating daily meals is not only a physical act of filling the belly to quench hunger but also it was considered a solemn and sacred act. Hence, the preparation of food was considered a pious religious deed purely performed by the women with great love, emotion, affection, and generosity.

Women as housewives thus play an important role in the practical application of serving excellent food with negligible wastage providing food security to the society. Hence after marriage the woman is considered queen of her husband's household.

Sacrifice in the interest of the family was considered an important virtue of Indian women. In several families even today, the housewife eats only after feeding everyone in the family. She sleeps only after all including servants, if any, have slept. She is the first to wake up in the morning. Thus she is not only a housewife but also a 'Goddess' residing in the house.

The custom, carrying a small idol of Goddess Annapurna by the bride is observed even today in several communities and families. Annapurna, as the name suggests, is the Goddess of food who assures food supply all the time. Another tradition observed is that when a bride enters her husband's house for the first time, she spills a tumbler full of food grains with a push of her foot. This tradition is symbolic of the women's role in assuring plenty of food grains in the house.

In the changing time, with the onslaught of Western culture values, the tendency to underestimate the role of housewife is gaining ground. Women of certain classes have started deviating from our traditional food and its preparation. They are being attracted to the commercially prepared or readily available instant food, endangering our home-kitchen institution. It seems that sooner or later we may lose traditional value of food and its management. Now it is up to the modern women whether they retain our traditional food management or accept the food management of the West.

Questions

1. Who developed the art of growing food crops first?
   (i) Men (ii) Women (iii) Men of pre-historic times (iv) Adam and Eve
2. Which of the following farm activities are carried out traditionally by women?
   (i) Sowing (ii) Transplanting (iii) Spraying pesticies (iv) Plowing
3. Which of the following activities are carried out commonly by women?
   (i) Feeding cattle (ii) Milking (iii) Fodder collection (iv) Chopping
4. In which activities the women have major role in silk production?
   (i) Mulberry cultivation (ii) Silkworm rearing (iii) Weaving (iv) Marketing
5. Annapurna is considered the goddess of:
   (i) Animals (ii) Food (iii) Human fertility (iv) Child protection

CHAPTER 5

CROP DOMESTICATION AND DIFFUSION

Crop Domestication

Crop domestication was a gradual transition from foraging practices which took place in several geographical regions of India. A large number of cereals and legumes used to be gathered by people for their survival. Later, it was felt necessary to have surplus food for non-producers and for use during natural and other calamities, which led to domestication of crops.

Survey of the use of wild species have revealed that more than 20,000 plant species are found in India of which 778 species belonging to 96 families possess edible plant parts. Survey conducted by NBPGR (National Bureau of Plant Genetic Resources) revealed that about 580 species of economic plants were domesticated and cultivated in India. Some of the major species are listed below:

- *Oryza sativa* (cultivated rice)
- *Triticum aestivum* (bread wheat)
- *Triticum dicoccum* (emmer wheat)
- *Hordeum vulgare* (hulled two-rowed and six-rowed barley)
- *Cajanus cajan* (pigeonpea)
- *Dolichos uniflorus* (horsegram)
- *Vigna aconitifolia* (moth bean)
- *Vigna mungo* (black gram)
- *Vigna radiata* (mung bean, green gram)
- *Brassica juncea* (Indian mustard)
- *Brassica campestris* var. *sarson* (yellow mustard)
- *Brassica campestris* var. *toria* (Indian rape)
- *Sesamum indicum* (sesame)
- *Abroma angusta* (perennial Indian hemp)
- *Corchorus capsularis* (white jute)
- *Gossypium arboreum* (cotton)
- *Amaranthus blitum* (*chaulai*)
- *Cucumis sativus* (cucumber)
- *Luffa acutangula* (ridge gourd)
- *Luffa aegyptiaca* (sponge gourd)
- *Momordica charantia* (bitter gourd)

- *Artocarpus heterophyllus* (jack fruit)
- *Citrus limon* (lemon)
- *Mangifera indica* (mango)
- *Morus alba* (mulberry)
- *Phoenix sylvestris* (Indian palm, wild date)
- *Crocus sativus* (saffron)
- *Curcuma domestica* (turmeric)

Wild rice was eaten at Chopani Mando about 10,000 years ago. Prolific use of husk and chaff of cultivated rice (*Oryza sativa*) as pottery temper at Koldihwa (c. 6500 BC) and Mahagara (c. 5400–4500 BC), and identification of grains of cultivated rice established the cultivation of rice at Mahagara (Belan Valley). This may be considered as the earliest rice domestication in South Asia.

The archaeological evidences show that hulled two-rowed and six-rowed barley along with wheat was domesticated in Mehrgarh (now in Pakistan). Apart from rice, barley, and wheat, legumes like green gram, black gram, and horsegram were also domesticated in India. Oilseeds domesticated in the country are Indian mustard, Indian rape, brown *sarson*, and legumes.

A number of "unconventional" cereals and millets which are still cultivated by the tribal people in various parts of India must have been domesticated by their ancestors. *Panicum sumatrense* (little millet), *Echinochloa colona* (*sawa*; shama millet), and *Sesbania bispinosa* are a few examples of minor millets and forage crops domesticated in India.

Diffusion of Crops

The cultivation of crops in areas other than its place of origin is called crop diffusion. When the people of a culture come in contact with the people of another culture, the act of "give and take" becomes beneficial to both of them. This spirit resulted in the diffusion of the crops. When the people started trading, they observed crops of the other area/country. They procured seeds of crops and started cultivation. During this process the farmers accepted only those crops which were high-yielders and suitable for their agroclimatic conditions. This resulted in the tremendous development of agriculture in different countries.

Agricultural crops did not diffuse from one center to the rest of the world. Carl Sauer, a geographer, tried to establish that agricultural revolution in the Old and New World took place at seven centers. He considered North India and South India as separate entities, which does not seem proper as both these regions are parts of Southeast Asia. Hence it seems that instead of seven centers there were only five centers of agricultural revolution (as given below).

1. The oldest center of diversity and origin of cultivated plant species was Southeast Asia (including North and South India) where rice, sugarcane, banana, coconut, jute, cardamom, citrus, mango, black pepper, turmeric, cotton, pulses, wheat, rye, linseed, apple, pear, and walnut were cultivated.

2. The second center was West Asia where wheat, forage crops, grapes, and almonds were cultivated.
3. The third center was China where soybean, litchi, loquat, tea, and some citrus species were cultivated.
4. The fourth center was the region including the countries bordering Mediterranean where oat, temperate fruits, cabbage, and cauliflower were grown.
5. The fifth center was Ethiopia (Africa) where wheat, sorghum, barley, castor, coffee, and watermelon were grown.

According to Sauer, the oldest center of diversity and origin of cultivated plant species was Southeast Asia. He divided this region into three parts: (1) North India which also included Myanmar in the East and Afghanistan and Iran in the West; (2) South India; and (3) Thailand, Malaysia, Indonesia, etc. It is interesting to note that maximum plant species were cultivated in North and South India.

The domestication and cultivation of rice started in Belan and Ganga Valley, Uttar Pradesh (c. 5440 BC). Rice cultivation diffused westwards to Gufkral and Pirak in Kashmir (c. 2000 BC), and also reached Lothal and Rangpur in Gujarat in 2300–2200 BC. Knowledge of rice cultivation from Ahar in Rajasthan, Dangwada and Navdatoli-Maheshwar in Madhya Pradesh, and Pandu Rajar Dhabi in West Bengal reflects the diffusion of rice in these regions.

Crops Introduced into Other Countries

The major crops that diffused to Middle East from India were rice, sugarcane, cotton, and lemon.

Rice

The crop from India first went to Iran, and then was accidentally introduced into Iraq in 700 BC when the Arabs conquered Basra. The interesting event that took place is given below:

"The Arab force found two baskets left by Persians, one containing dates and the other something new material to them (actually it was husked rice). The Arab Commander told his men: 'Eat dates but not the other one which seems poison.' They therefore, ate the dates and left the un-husked rice as such. Somehow a horse came and started to eat rice. When they saw a horse eating rice they decided to slaughter the horse so that they could eat before its flesh got poisoned. The horse owner then requested to wait for the next day. Next day they saw that the horse was still in excellent health. Then they lit a fire under the un-husked rice and burned the husk. The Commander then said: 'Pronouncing the name of Allah, let us eat.' They ate and found it most tasty food."

Sugarcane

Sugarcane was another crop that was introduced into Persia from India. During the Islamic Middle Age, the cultivation and preparation of sugar spread to Egypt and North Africa. The cultivation of sugarcane was carried from North Africa to Spain from which it reached Atlantic Island and

eventually to New World. Interestingly the semisolid stage called *raab* during refining of sugar was mistaken by Alexander for honey and he thought that India had a plant that produced honey.

Cotton

Cotton diffused to Persia from India around 630 AD. From Persia it was carried to Middle East and then westwards. The Greeks, seeing cotton for the first time, thought it was the wool from a plant.

Lemon

The Muslim caravan-traders introduced lemon into Middle East from India around 900 AD. The sweet lemon (orange) was introduced into Middle East by the Portuguese merchants in the beginning of 1600 AD. The cultivation then spread over across the Middle East and from there into Europe.

Crops Introduced into India

A number of crops were diffused into India from other countries. All the exotic crops did not diffuse together, but followed one another. For example, naked barley after hulled barley, bread wheat after dwarf and club wheats, and finger millet after sorghum.

The highlands of Peru, Ecuador, Bolivia, Southern Mexico, and Central America are considered to be the center of origin of maize. Maize diffused into several countries of Old and New World from these countries.

Several species of winter cereals, legumes, and other crops were domesticated in Southwest Asia and diffused into India around 1000 BC. Likewise, the other crops, viz., sorghum, finger millet, and pearl millet were domesticated in Africa and diffused into India around 2000 BC.

The major crops introduced from other countries/regions into India are listed below:

- Portugal
  - *Amaranthus* spp. (amaranth)
  - *Arachis hypogaea* (groundnut)
  - *Cucurbita moschata* (squash)
  - *Ipomoea batatas* (sweet potato)
  - *Solanum tuberosum* (potato)
  - *Anacardium occidentale* (cashew)
  - *Psidium guajava* (guava)
  - *Nicotiana tabacum* (tobacco)
  - *Capsicum annuum* (chili)
- Britain
  - *Avena sativa* (oat)
  - *Pisum sativum* (field pea)

- *Gossypium barbadense* (cotton)
- *Brassica oleracea* var. *botrytis* (cauliflower)
- *Brassica oleracea* var. *gongylodes* (knol-khol)
- *Lycopersicon lycopersicum* (tomato)
- *Daucus carota* (carrot – orange type)
- *Carica papaya* (papaya)
- *Fragaria* × *Ananassa* (strawberry)
- *Malus pumila* (apple)
- *Prunus persica* (peach)
- *Cinchona officinalis* (quinine)
- *Papaver somniferum* (opium poppy)
- *Coffea arabica* (coffee)

• West and Central Asia
- *Allium cepa* (onion)
- *Allium sativum* (garlic)
- *Brassica rapa* (turnip)
- *Brassica oleracea* var. *capitata* (cabbage)
- *Coriandrum sativum* (coriander)
- *Cucumis melo* (sweet muskmelon)
- *Daucas carota* (carrot – black and red type)
- *Phoenix dactylifera* (date palm)
- *Syzigium aromaticum* (clove)
- *Vitis vinifera* (grape)

• China
- *Eriobotrya japonica* (loquat)
- *Juglans regia* (walnut)
- *Litchi chinensis* (litchi)
- *Glycine max* (soybean)

• Latin America
- *Hevea brasiliensis* (rubber)
- *Ananas comosus* (pineapple)

• Spain
- *Phaseolus vulgaris* (French bean)

• Africa
- *Sorghum bicolor* (sorghum)

- *Eleusine coracana* (finger millet; *ragi*)
- *Pennisetum glaucum* (pearl millet)

- Southwest Asia
- *Triticum* spp. (wheat – all types)
- *Hordeum vulgare* (barley)
- Several legumes

In recent years, the following plant species were introduced into India:

- *Helianthus annuus* (sunflower)
- *Cyphomandra betacea* (tree-tomato)
- *Mentha arvensis* (spearmint)
- *Actindia chinensis* (kiwifruit)
- *Acacia senegal* (gum-arabic)

The diffusion of crops changed the subsistence pattern. The changes in pattern were brought by:

- Gradually replacing high-yielding emmer, dwarf, and club wheats by high-yielding bread wheat.
- Incorporating several crops like oat and fenugreek for cultivation in winter.
- Cultivating rice and Indian legumes in rainy season.
- Replacing Italian millet by sorghum and finger millet.

The process of diffusion thus increased the economic prosperity, when the farmers started raising a number of crops, fruits, and vegetables suited to different agroclimatic conditions of dryland and wetland farming systems. This crop rotation resulted in extensive land use practices which enhanced the development of agriculture.

Transfer of Technology

With diffusion of crops in different regions the technology was also transferred with them. In India several technologies were developed which were shared by other countries.

Rice

The art of rice transplanting was independently developed in India more than 2000 years ago. This technology was adopted by several countries and also moved westwards.

The technology of cultivation of rice in Assam was well developed. It was taken by Tai tribe to Thailand and was used to develop their cultivation in irrigated rice. Technology of cultivation of short-duration and relatively drought-tolerant varieties of rice grown in India was taken to Vietman and Cambodia. These short-duration varieties were then introduced into China. These varieties matured in 100 days after transplanting as compared with 150 days of Chinese cultivars. Chinese made further improvement in these cultivars and

reduced the maturity period to 50–60 days. Thus, they made revolutionary change by taking 2 to 3 crops a year.

Sugarcane

Sugarcane was introduced from India to Persia which spread over to Egypt and North Africa. The technology of sugar preparation from sugarcane was also transferred from India to these countries.

Black pepper

Portuguese merchants took away pepper vines from Malabar region of India for cultivation especially in East Indies (Indonesia) but it could not be cultivated there due to lack of technology. Later they took the technology from India and improved it as per their agroclimatic conditions. Indonesia is now a strong competitor with India in pepper trade.

Cotton

Similar to sugar preparation, the Indian technology of yarn and textile production was transferred to Middle East and then westwards.

Additional Notes

Irrigation

India was the first country to build reservoirs and tanks to facilitate irrigation. The practice enabled the farmers to take more than one crop a year. This technology went to the East and the farmers benefited from it.

Cattle feed

In Vedic period cow has been termed as the "Mother" and worshiped. Indians kept cows and every care was taken for her diet and comfort. They were paying full attention not only to cows but also to other cattle that they domesticated. The technology developed by Indians regarding feed rations of cattle was followed later by many countries.

Milk

The traditional knowledge of milk heating (simmering), i.e., slow heating for a longer time on the fire of dried cow dung cake was highly prevalent in India. The Western countries did not know the importance of heating milk until much later.

Rainfall prediction

India was the first country to develop and use astrological models for predicting the monsoon rainfall. The models were adopted by other countries to predict rainfall for the use of farmers.

Persian wheel

There is a general belief that the Persian wheel was developed in Persia, but it is not true. The wheel existed in Pre-Islamic India. It is present in the sculpture of 11th century at Mandor

(Jodhpur, Rajasthan) in a Hindu temple. It is likely that Islamic invaders took the wheel with them to Persia and thus called it the Persian wheel.

Plow

The Indian wooden plow was one of those agricultural implements which the British considered "imperfect". They, therefore, tried to introduce the iron plow among Indian cultivators. The response of Indian cultivators to this plow was not encouraging because it was heavy and costly. However, the use of iron-share in native plow was readily adopted. Similarly, the Indian cultivators also accepted the iron rollers for crushing sugarcane replacing their traditional stone rollers.

Questions

1. Crop species that were domesticated in India was/were:
   (i) *Oryza sativa* (ii) *Vigna mungo* (iii) *Glycine max* (iv) *Avena sativa*
2. The following crop(s) was/were introduced into India by Portuguese:
   (i) Groundnut (ii) Potato (iii) Papaya (iv) Tomato
3. The following crop(s) was/were introduced into India from Africa:
   (i) Sorghum (ii) Pearl millet (iii) Barley (iv) Groundnut
4. Which was the first country to build water reservoirs for crop-irrigation?
   (i) Thailand (ii) India (iii) Iran (iv) Greece
5. Persian wheel for crop irrigation was first invented in:
   (i) Iran (ii) India (iii) Iraq (iv) Syria

CHAPTER 6

ANIMAL HUSBANDRY

The importance of animals was known to man well before he started organized agriculture. Man gets a number of useful products from animals, like food, skin, hide, manure, power, etc. and as such the domesticated animals have become an integral part of agriculture and rural life. In India, animal husbandry was well-organized in ancient and medieval periods. Indians of Vedic age recognized the importance of animals and, therefore, they began to manage the forests and pastures for protecting and grazing their animals. They used to graze their cattle by taking them to pastures or grasslands in the morning and bring them back in the evening, the practice which is still seen in the villages of India.

Ancient Period

Cattle and other domesticated animals were considered as wealth and paramount importance was given to their management. The information on the kinds of animals, animal behavior, and man-animal relationship has been given in Rigveda.

Cows

A cow having long nose was considered good and preferred by the ancient people. Cows were kept in the barn during cold weather and were given grass of good quality, barley, sugarcane, and sesame oil cake as feed and fresh water to drink. Boys used to look after the cows while grazing in the forest or grassland. Cow's milk was a significant food and was considered like honey. Cow dung was used as fuel. This practice is followed even today. In Vedas, cow is referred as "*Aghanya*", which means not to be killed but protected. The people of ancient India considered that whole cow family or "*Gau vansh*" was essential for existence of humanity. Cow's milk provided special energy, strength, and intelligence. Cow dung and urine nourished the crops. Bullock power helped in the development of techniques in agriculture like plowing, irrigation, and transportation. Skin from dead cow supported leather industries. Therefore, cow has always been a core point in the economy during ancient period. The religious priest who had the responsibility of maintaining cows was first animal healer or veterinarian. A number of Vedic hymns indicate medicinal values of herbs. The Atharvaveda mentions about healing herbs like *arjuna* (*Terminalia arjuna*), *kadamba* (*Anthocephalus cadamba*), *ashoka* (*Saraca asoca*), neem (*Azadirachta indica*), etc., which were widely used to keep the cows and other animals free from ailments.

Cow in Krishna's era

In Mahabharata, references have been made to many domestic animals including cattle, sheep, goats, dogs, elephants, and horses but cow has been given prime importance. During Krishna's era cow husbandry was well developed in Mathura (Uttar Pradesh). Cow milk, curd, butter, etc. were produced in sufficient quantities. People of Brij region used to pay tax to King Kansa in the

form of milk and butter. Krishna stopped it. He began to worship cows on the day after *Deepavali* festival in place of Lord Indra.

Panchagavya

The five products of cow are called *Panchagavya*. These include milk, curd, ghee (clarified butter), cow dung, and cow urine. Our ancestors used these products to keep the body and mind healthy and also to keep the environment free from pollution. The scientific evaluation of these products now has revealed that these elements enhance the immune responses of the body when used individually or collectively. The "*Kamdhenu ark*" prepared from cow urine is effective in the treatment of kidney disorders. It has been found to increase phagocytosis by macrophages and thus is helpful in the prevention and control of bacterial infections. The cow urine has antioxidant property and protects DNA damage due to mitomucin-C induced chromosomal aberrations. Similarly cow dung keeps the environment free from pollution and does not allow any radiation effect. Now the world has understood why the walls of the house in ancient period were plastered with cow dung. Cow dung also contains plenty of methanol, ammonia, phenol, indole, and formalin. The bacteriophages present in cow dung eradicate the pathogens. Most of the skin diseases can be cured by its application. Cow milk, curd, and ghee are well known for their high nutritive value. Cow milk is a unique blend of 101 substances. Curd and butter milk (*mattha, chhachh*) are good appetizers and keep the digestive system normal through sustainable maintenance of pro-biotic bacteria. Ghee has been reported to improve memory and reduce mental tension. However, it is generally believed that "*Panchagavya* therapy" is useful only when the elements of *Panchagavya* are obtained from the healthy and well-pastured Indian native cow. *Panchagavya* products obtained from the cows of "*Goshala*"[1] where forced feeding is done may not be effective to that extent. The use of *Panchagavya* has not been suggested in any of the agricultural texts discovered so far. It is used as a fermented product in agriculture today, but fermenting *Panchagavya* makes it a *Kunapajala* (liquid manure) preparation.

Other animals

Apart from cow, a number of other animals like sheep and goat, horse, donkey, camel, etc. have been mentioned in Vedas. *Avi* is a Sanskrit word that means sheep. The hair (wool) of sheep was used mainly in garments and carpets. The wool of goat having long hair was used for making woolen fabrics. The art of weaving was well-known to ancient people.

Buffalo was not a commonly used animal in the ancient period. It appears the ancient people preferred cow for milk. They kept dog for guarding houses and hunting. Horses, camels, and donkeys were used for riding and possibly for carrying loads. It is interesting to note the reference to chickpea as a horse feed in Rigveda. Even today water-soaked chickpea is considered to be a good feed for animals.

1. *Goshalas* are protective shelters in India for cows that have been neglected. *Goshalas* focus on treating cows in accordance with Hinduism philosophy.

Cattle management

Sage Parashara (c. 400 BC) in his treatise "Krishi-Parashara" described cattle management in detail (verses 84–111). He emphasized cattle sanitation, health, and nutrition. Regarding the space required for cow or bullock, Parashara recommended about 6.5 m^2 per animal. Even today the recommended area per cow is about 6 m^2.

Parashara recommended wheat, barley, and other grains as feed for cattle in addition to grazing. The best feed was sugarcane. Sugarcane still continues to be the best fodder. However, during feeding of cattle certain precautions are described:

- Water kept in bronze pot should not be given to cattle.
- Hot scum of boiled rice or any other grain should not be given.
- Water used for washing fish is prohibited for cattle.
- Ginned cotton should also not be given to cattle.
- Leftover food should not be given to cattle.

Water in bronze utensil could give more copper to the cattle which may be harmful. Hot scum that contains impurities from the grain being cooked does not have any nutritional value. The fish water may contain bacteria which may be harmful to cattle. Ginned cotton fiber may get into nostrils causing irritation to cattle. The leftover food may harbor microorganisms that may adversely affect the health of the cattle. These may be the reasons for making such prophylactic measures.

Cattle festivals were celebrated by ancient farmers. The only purpose of such celebrations was to develop a sense of care for cattle among the people. On the days of these celebrations, the cattle were washed and horns were decorated. The body and horns were smeared with a mixture of oil and turmeric powder. This was done to disinfest the body of the animal and also to heal the minor injuries on the body, if any.

Parashara recommended that each farmer should have two pairs of bullocks. Perhaps he might have considered the division of labor and also that agricultural operations may not be stopped due to ailment of the bullocks as at least a pair of healthy bullocks is always available for work. Also alternate use of bullock pairs gives adequate rest to both the bullock pairs.

Era of Buddhism and Jainism

Jains being strict followers of non-violence believed that cultivation of soil causes violence to living beings. Hence they adopted the profession of trade and moneylender. During this period (600 BC through 500 AD) animal protection was at its peak and the animals were considered as an integral part of human life. The householders used to keep the domestic animals, viz., cows, oxen, bulls, buffaloes, sheep, horses, ponies, asses, camel, and elephant for milk, wool, conveyance, sports, etc., but essential duties for the people were prescribed. Some of these are as follows:

- Animals should be given food and drinking water on time.
- Animals suffering from ailments should be treated properly.
- Animals should be protected from their predators as well as from extreme weather conditions.

Neglecting to perform these duties and to cause pain to animals in any manner were considered laxity in vow which was punishable.

Buddha also preached non-violence towards animals. The earliest Buddhist text "Sutta Nipata" describes cattle as providers of food, beauty, and happiness, and therefore deserve protection.

Era of the Mauryans

During Mauryan period (321–185 BC) animal husbandry made great progress. According to "Kautiliya Artha-sastra", cow was worshiped. It was the duty of the king to worship cow with her calf and bull. The killing of cow was considered a deadly sin. Buffalo and goat were also considered as milch animals during this period. Artha-sastra mentions dry straw (called *trina*) and green fodder (called *yavasa*) separately indicating a clear concept about green and dry fodder in the feeding of milch animals. Similarly feeding of oil cake has also been recommended for cow. Kautilya recommended the appointment of separate Superintendent for cows, horses, and elephants, who was responsible to take care of these animals. The horses and elephants were trained for warfare. There were about 6000 elephants with the King Nanda and about 9000 with Chandragupta.

Medical Care in Ancient Period

In ancient India animals received good medical care. Apart from physicians who treated human beings, there were physicians who specialized only in animal care. Shalihotra was the first veterinarian in the world and is considered father of veterinary science in India. The inscription on the rock in Girnar in Gujarat indicates that Ashoka (304–232 BC) made two types of hospitals in his kingdom, one for human beings and the other for animals where the treatment of animals was carried out with great care and precision by well-trained personnel.

Before the advent of modern allopathic system of medicine, people were largely dependent on locally available plant resources to meet their medicinal requirement. This system of medicine is termed ethno-medicine and relates to human treatment, while the term ethno-veterinary medicine refers to treatment of animals. Shalihotra has documented several medicinal plants which cure the ailments of animals. Similarly Palakapya wrote "*Hasta* Ayurveda" or "*Gaja* Ayurveda" which deals with the diseases of elephants and the treatment. It also deals with the classification, anatomy, and training of elephants.

Veterinary Medicine in Ancient Period

In ancient times, several herbal medicines were used for the treatment of different animal diseases like diarrhea, fatigue, cough, hematuria, diseases of horn, pain in head and teeth, wounds, skin diseases, anorexia, tumor, conjuctivitis, bronchitis, etc. Lokopakara (1025 AD) describes some of the diseases and their remedies. Some medicinal plants used for the treatment of animals are given in Table 1.

Table1. Indigenous plants for the treatment of diseases of animals.

Sanskrit name of plant	Latin name of plant	English name of plant	Used to treat diseases
Haridra	*Curcuma domestica*	Turmeric	Anemia (*pandu*)
Vasa	*Adhatoda vasica*	Malabar nut	Headache and skin diseases
Ativisha	*Aconitum heterophyllum*		Diarrhea (*atisar*)
Brahti	*Solanum indicum*	Indian nightshade	Headache and hematuria (*raktameh*)
Bilva	*Aegle marmelos*	Bael	Fruits were used to treat diarrhea
Draksha	*Vitis vinifera*	Grape	Hematuria
Kulatha	*Dolichos uniflorus*	Horsegram	Sore throat
Manjishtha	*Rubia cordifolia*	Indian madder	Hematuria and pain in ear
Musta	*Cyperus rotundus*	Nut grass	Diarrhea
Yasthimadhu	*Glycyrrhiza glabra*	Licorice	Headache (*shirashool*)
Shunthi	*Zingiber officinale*	Ginger	Cough and diarrhea
Hingu	*Ferula assafoetida*	Asafetida	Pain in ear (otalgia) and headache
Trikatu (*Shunthi, Krishna, Kana*)	Mixture of *Zingiber officinale*, *Piper nigrum*, and *Piper longum*	Mixture of ginger, black pepper, and long pepper	Anorexia (*aruchi*) and tumor (*gulma*)
Nimba	*Azadirachta indica*	Neem	Headache and skin diseases
Vidanga	*Embelia ribes*		Intestinal worms

In the context of present knowledge these herbal medicines have insecticidal, fungicidal, and antimicrobial properties. In addition they contain chemicals which may induce host resistance to pathogens. For example, the bark of *arjuna* has antibacterial property; *ativisha* and *vidanga* act as insecticides and also have antibacterial property. *Ativisha* was used for the treatment of diarrhea. Similarly, *trikatu*, a mixture of *shunthi*, *krishna*, and *kana* has antibacterial, larvicidal, and anthelmintic properties. *Shunthi* was given for the treatment of cough. Oleoresin and alkaloid piperin present in *krishna* impart antifungal and insecticidal properties, respectively. *Vasa* had been found very useful as it has antibacterial, antifungal, antiviral, insecticidal, acaricidal, and herbicidal properties.

Medieval Period

In the medieval period animal keeping was done by the age-old traditional methods. Cattle were important and cow was considered 'mother'. Besides cow, sheep and goat were also considered valuable for providing livelihood to rural population. Since the medieval period is characterized by the internecine attacks by Turks, Arabs, Afghans, Mughals, and then by Europeans, main emphasis was given to the animals like horses and elephants that were used for warfare.

Approximately 10,000 horses of good quality were imported for the rulers of South India. Alauddin Khilji had about 500,000 horses in his army. Similarly, the Sikh Guru Arjundev encouraged Sikhs to have horses from Turkistan. Sikhs were trained to become excellent horse riders. The stable of Guru Govind contained 800 good quality horses. Horses were bred in the forest of Bhatinda in Punjab and Maharaja Ranjit Singh had a large cavalry. Likewise, equine breeding was established in 1795 AD to supply horses to the army of the East India Company. Army veterinarians were appointed for the first time in British Army in 1796. At that time grasses such as Dutch clover, guinea grass, and lucerne were grown as fodder for the first time in India.

The Chalukyan king Someshvardeva (1126–1138 AD) had a large number of elephants. Elephant sports were very popular during his reign. The historic Kingdom of Vijayanagar had a large number of elephants as evidenced by the remains of elephant stables in the ruins of Humpi, the capital city. In the Mughal period elephants were used in warfare and also elephant fights were arranged as sport.

Animal husbandry was well developed in the Himalayan state of Kumaon. There were three positions of Superintendent related to animal husbandry. Similarly during Mughal period much emphasis was given to animal husbandry. The Mughal Emperor Akbar was an animal lover. He assigned specific responsibilities of livestock development to his cabinet ministers. To win the confidence of Hindus he issued a royal order banning cow slaughter. In the famous text, "Ain-i-Akbari", Abul Fazl mentions the natural habitats and breeding places of different species of domesticated and wild animals. Descriptions of feeding and water requirements of the domesticated animals are also given in this text. Like Akbar, his son Jahangir was also a great lover of animals. He took special interest in the behavior of wild animals. The text Tuzuk-i-Jahangiri provides a great deal of information on tigers, horses, elephants, goats and sheep, monkeys, and birds. Descriptions of outbreaks of plague in animals, cases of rabies in elephants, experiences with consuming camel milk, and fat-tailed sheep are also available in this text. He has also mentioned the veterinary medicines used at that time. During 18th century, Tipu Sultan of Mysore did outstanding work in animal breeding. He encouraged breeding of domestic animals and appointed "Nalbands" (farriers) who looked after the breeding of horses. These officials discharged their duties as the present-day veterinarians do.

The early British were critical of the native's knowledge of medicines and therefore, introduced new practices as required by the army of the East India Company. Therefore by the end of medieval period, both Ayurvedic system of medicine and Indian livestock were neglected.

Questions

1. The first mention of specific medicinal plants for treating animals is made in:
   (i) Rigveda (ii) Samaveda (iii) Atharvaveda (iv) Charaka Samhita
2. In which text, cattle sanitation, health, and nutrition have been described?
   (i) Surapala's Vrikshayurveda (ii) Mriga.pakshi.shastra (iii) Krishi-Parashara
   (iv) Vishvavallabha

3. According to Parashara, how many pairs of bullocks a farmer must keep for draft purpose?
   (i) One pair (ii) Two pairs (iii) Four pairs (iv) Six pairs
4. In which text does one find specific mention of green and dry fodder for milch animals?
   (i) Kashyapiyakrishisukti (ii) Brihatsamhita (iii) Kautiliya Artha-sastra (iv) Surapala's Vrikshayurveda
5. The first veterinarian of the world was:
   (i) Susruta (ii) Charaka (iii) Shalihotra (iv) Palakapya

CHAPTER 7

FISHERY

Fish had been perceived as an object of entertainment and sensation by man due to its color, graceful swimming, and swiftness against disturbance. Its food value was recognized later, i.e., after that of terrestrial animals and avians. Boiling of fish to obtain oil was started by man in pre-historic time. This oil was used to light lamps. Thus it is the fish which for the first time gave light to man. The presence of fish bones in the caves of early man of Stone Age, which were situated far from rivers and seashore, indicated that hunting fish for food and their transportation was well developed at that time.

In Yajurveda there is mention of capturing fish by sedating them by treating the pond water with bark of some unidentified tree which reveals that use of fish as food was also known to our ancestors.

Excavations made by archaeologists and paleontologists in different parts of India revealed that angling was a common method of catching fish in ancient India. In Sindhu Valley fishing was done by using nets and fishing hooks were made of animal bones and iron. In excavations at Ganeshwar in Sikar district of Rajasthan, about 50 fish hooks of 2000 BC were found. Potsherds with impressions of fish net were recovered from the excavations at Etta (Uttar Pradesh) that date back to 1200–600 BC. It is evident that in India fishing has been an important activity as a part of the food supply in wide variety of situations.

People of Sindhu Valley were great mariners and seem to have established their colonies in the Middle East Gulf countries. The painting of marine fishes on pottery of Harappa period indicated that Harappans were familiar with marine fishing. Several fish hooks recovered from Mohenjo-daro, Harappa, Chanu-daro, Lothal, and other sites located in the coastal belt of Gujarat had great similarity between fish hooks of Sindhu Valley sites and modern ones which show the continuity of cultural traits.

Introduction of Fish Culture in India

Introduction of fish culture in India is not exactly known. It is believed that fish culture was introduced in India from China via Thailand and Malaysia. It first came to Myanmar (previously a part of India) and then to East Bengal (now Bangladesh) and West Bengal which have climatological similarity with East Asian countries. Further spread of fish culture took place to the adjoining state of Bihar and then to Orissa and Madhya Pradesh. Incidentally fishes by name have been mentioned in Mahabharata.

In "Kautiliya Artha-sastra", Kautilya mentioned the method of poisoning fish in ponds during war which indicated that fish culture was practiced around 300 BC in Bihar. Varahamihira

(c. 505–587 AD) of Ujjain (Madhya Pradesh) recommended the cultivation of vegetables on the banks of ponds which were used for fish culture; the practice is followed till today. The pillar called 'fisherman' monument and fishing carvings on stone pillars of Gupta period are few evidences of fish culture prevailing during that period.

About 1000 years ago, Surapala mentioned the importance of fish as manure in "Vrikshayurveda". Verse 102 of Vrikshayurveda describes: "As per availability, the fat, the marrow, and the flesh of fish, the ram, the goat and other horned animals should be collected and stored." These materials were used to prepare "*kunapa*" or liquid manure for better growth of trees. Similarly verse 117 mentions: "The trees yield rich reward in the form of flowers and fruits in a very short period when smoked with a mixture of plantain leaves, white mustard seeds, and a small, shining variety of fish."

In South India fish culture was well developed in the medieval period. The Chalukyan king Someshvardeva wrote "Manasollasa" around 1131 AD. In this treatise different aspects of fish culture have been described in detail. About 35 different kinds of fishes have been described which were not only used for entertainment but also for food. Some of the fishes which were used as food are listed below:

- *Kahlava* (*Catla catla*)
- *Mahashila* (*Tor tor*)
- *Kovasaka* (*Mystus seenghala*)
- *Pathina* (*Wallago attu*)
- *Rohita* (*Labeo rohita*)
- *Vadisha* (*Acrossocheilus hexagonolepsis*)
- *Kovakiya* (*Pseudosciaena sina*)
- *Simhatundaka* (*Bagarius bagarius*)
- *Marila* (*Channa marulius*)

Pond Construction

The ancient people knew that for construction of ponds for fish culture, clayey soil is most useful. Therefore, they used to construct ponds in the areas having clayey soil. As there were no soil testing equipment and methods, which we have today, they developed their own indigenous method. In this method they used to make a small ball of wet soil from the site. This ball was thrown upwards and then allowed to fall back on the ground. If the ball broke after falling on the ground, the site was considered unfit for construction of pond for fish culture. But if the ball remained intact the site was accepted as suitable for the construction of pond. This age-old method is practiced even today to select the site for the construction of pond in rural areas where modern soil analysis facilities are not available.

The use of cow dung to stop or reduce water seepage from the pond and also to increase the productivity of the pond was known to Indians. This method is still the best and

cheapest, and quite harmless in reducing seepage and simultaneously increases the pond productivity.

The use of organic manure both in agriculture and aquaculture has led to the development of various systems of aquaculture by integration with agriculture, horticulture, and livestock.

Integration with Agriculture and Horticulture

Rice-fish culture and horticulture-fish culture were known to our ancestors. The integration of aquaculture and agriculture was started in India and this practice was introduced to Southeast Asia from India about 1500 years ago. Rice-fish culture was practiced in waterlogged rice fields and brackish water in "Sunderban" area of Bengal. Fish-horticulture integration was suggested long back by Varahamihira that has a much wider application today. These integrated systems led to increase in food production giving a fish farmer an additional income.

Integration with Livestock

One of the aspects of integration of fish culture and livestock is the utilization of animal waste. Surapala in "Vrikashyurveda" suggested the use of animal waste, bones, blood, etc. for the preparation of "*kunapa*", a liquid manure which was very good for the development and growth of trees including fruit-bearing capacity and quality of flowers and fruits.

In fish-livestock systems large quantities of cattle excreta were added to the pond. This along with fish excreta would settle at the bottom of the pond in the form of silt which was removed from the pond and used for agricultural purposes. The cattle excreta is most stable because of reapeated grinding and digestive decomposition catalyzed by the microorganisms in the rumen of cattle. It is established that cattle excreta has the lowest Biochemical Oxygen Demand (BOD) amongst all livestock manure. Therefore, its application does not lower the level of dissolved oxygen in the water to a dangerous level. Thus plenty of dissolved oxygen is available to fishes and other aquatic organisms in the pond water. Further, out of the grass consumed by the cattle about one-third grass is leftover which was also used as fish food.

Fish Conservation

Fish conservation in ancient India was ensured by imposing strict laws. During the Mauyarn period, seeing the importance of fishes three laws were imposed:

1. No fish should be caught on the 14th and 15th day of full moon and the first day after full moon during the period of third *Chaturmasa*, i.e., *Shravana* (August), *Bhadrapada* (September), *Ashwin* (October), and *Kartika* (November). This restriction was for 12 days, i.e., 3 days in each month.

   This rule of restriction was based on a scientific principle. The period notified in the law is the breeding season of fishes. Presently the restriction in catching fish is July/August and September but the prohibition period was extended up to the middle of November by Mauryans. The reason was that after breeding in shallow areas or rivers, the fishes fall back to their

normal habitat in deep water. The young ones and spent fishes need protection at this stage. Even today as the *Hilsa* fish moves to estuaries, people of Bengal do not eat *Hilsa* fish after *Durga Pooja* in October until *Saraswati Pooja* in end of December.

2. No fish should be caught on the fast days, i.e., *Amavasya* (new moon) and *Ashtami* (the 8th day) during every fortnight period of new moon. This duration was 36 days (12 *Amavasya* and 24 *Ashtami*).

   Besides the main edible fishes, there are other varieties of fishes which do not breed in rainy season but breed in other times of the year. This rule gives protection to them. In addition the fishermen themselves observed fast on those days and did not consume fishes. In this way the fishes were conserved without affecting the trade significantly.

3. No fish should be caught on 14th and 15th day of full moon and 1st day after full moon of *Pausha* (January). The duration was 3 days.

   The significance of this rule was to protect fishes during the peak cold season when fishes in North India were benumbed, losing much of there vitality.

Thus fishing was prohibited for 51 days in a year.

Fish Food

In Manasollasa, Someshvardeva described various materials to feed the fishes. He mentioned that *Kahlava*, *Rohita*, and *Vadisha* should be fed on vegetarian diets like ground sesame, flours including roasted flour of chickpea, cooked rice, etc. *Kovakiya* is a fish which is both vegetarian as well as non-vegetarian and can be fed with vegetarian diet and meat items. *Pathina*, *Marila*, and *Simhatundaka* are the fishes which should be fed with flesh.

Transportation of Fish

The traditional knowledge of fish transportation was not unscientific when judged in the light of modern science. The transport of live fishes was done in earthen pots known as *handis* which kept the water cool thereby dissolving more oxygen and keeping the temperature low. As we know today, low temperature and oxygen are the two most essential criteria for live-fish transport. Further, intermittent shaking of the *handis* by hand creates turbulence which results in higher diffusion of oxygen in the water. Thus we see that the modern live-fish transportation has taken into account the basic principles of traditional method practiced and perfected by our ancestors.

Fish and Religion

In Hindu mythology, the fish is believed to be the first incarnation of Lord Vishnu known as "*Matsyavatara*". It is said that "*Matsyavatara*" gave the first guidebook on management, society, religion, food preferences, and other aspects of life. The discourses given by "*Matsyavatara*" during the journey from Sea to Himalayas have been complied in Matsya Purana.

In West Bengal, before the marriage ceremony, gifts are exchanged between the families of bride and bridegroom. The important gift is the fish *Rohu* (*Rohumachha*; *Rohita*). Here fish is

considered a symbol of love, affection, and appreciation. When a bride enters her husband's house, she has to touch the live fish and then eat cooked fish in the wedding party. The fish is also considered a symbol of fertility in West Bengal. A widow is therefore forbidden to eat fish. In no part of India, the fish has been institutionalized in the social network as in West Bengal.

Even today, God of Sindhi community "Jhulelal" is shown sitting on a fish called "Palla". This "Palla" is *Hilsa* fish abundantly found in the river Sindhu.

Questions

1. The oldest reference to capturing fish through herbal sedation is found in:
   (i) Rigveda (ii) Yajurveda (iii) Atharvaveda (iv) Kautiliya Artha-sastra
2. Earliest use of hooks and nets for fishing was made by people of:
   (i) Saraswati civilization (ii) Indus civilization (iii) Ganga civilization (iv) South India
3. Which of the following fishes were considered edible according to Manasollasa?
   (i) *Sora* (ii) *Shringasora* (iii) *Kahlava* (iv) *Simhatundaka*
4. In which months fishing was prohibited during the Mauryan period?
   (i) *Bhadrapada* (ii) *Kartika* (iii) *Chaitra* (iv) *Aashadha*
5. Which of the following were used for sealing the bottom of fish ponds to prevent seepage?
   (i) Fine clay (ii) Cow dung (iii) Elephant dung (iv) Decomposed vegetation

CHAPTER 8

AGRICULTURE IN KAUTILYA'S ARTHA-SASTRA

"Fools rely on fortune and stars", said Kautilya who was a great scholar and politician. In 321 BC he placed Chandragupta Maurya on the throne of Magadha overthrowing Nanda dynasty. Kautilya or Chanakya or Vishnugupta was the chief advisor of Chandragupta Maurya. Being a brilliant intellectual, Chanakya wrote a treatise popularly known as "Kautiliya Artha-sastra". His main aim was to give an administration for the betterment of the common people. He was renowned not only as king-maker but also for being the greatest exponent of the art of government, the duties of the king, ministers, officials, and methods of diplomacy. Being the basic component of human society, agriculture has been given high importance by Kautilya.

Kautilya grouped all the industries into two categories according to their ownership; first, owned by the state and second, owned privately. Agriculture was placed in the category of privately owned industry. Although agriculture was placed in the private sector, Kautilya clearly mentioned that the production, distribution, and consumption of agricultural products would be controlled by the king.

Agriculture

Kautilya gave great emphasis to agriculture and suggested a separate post of Head of Agriculture (Superintendent) and named it "*Sitadhyaksha*" who was made accountable to the state and agriculturist for all the farming practices.

Land use

The Artha-sastra of Kautilya gave much importance to land reform and land use which were very crucial in agricultural development. The whole cultivable land must be cultivated and no piece of cultivable land should remain unsown. The fields left uncultivated by the king or private owner because of shortage of manpower should be given for cultivation to those who are ready to cultivate the land for half the share in the produce (*Ardhasitika*). The land may also be given to those who share any physical work for one-fifth share of the produce obtained. Kautilya knew that land left unsown would ultimately affect the production adversely.

Rainfall

Although there were irrigated lands yet a major area was rainfed. Kautilya described that 16 *dronas* (1 *drona* = 6.4 cm) rainfall is sufficient for high yields of crops in dry areas whereas in humid areas 24 *dronas* rainfall would be optimum. For regional crops, he mentioned that 13.5 *dronas* for Ashmaka (Marathwada region of Maharashtra), 23 *dronas* for Avanti (Malwa plateau in West Madhya Pradesh) would be optimum. The Aparanta (Konkan region of Maharashtra) and Himalayan regions get immense quantity of rain. Depending upon rainfall in different regions the crops were sown by *Sitadhyaksha*. Kautilya has described the technique for measuring

rainfall in detail. For this a circular vessel with a diameter equal to the length of a human arm and a depth equal to the distance measured by the width of eight fingers was used to collect water. In modern units, the diameter and depth would be approximately 45 cm and 13 cm, respectively. When this vessel was filled with rain water, collected in open space, rainfall was measured to be 50 *palas* or 1 *adhaka* or ¼ *drona* (1 *adhaka* = 1.6 cm in modern units).

Although Parashara (c. 400 BC) described the technique for measurement of rainfall by identifying the type of "ruling clouds", it was somewhat primitive and difficult to understand. The method of measuring rainfall by Kautilya represents a higher stage of evolution and due to its simple and refined form, it was acceptable to the agricultural community.

Seed

Kautilya considered seed as the most important component of agriculture and, therefore, gave much emphasis on the procurement of quality seeds, their preservation, production, and distribution. The *Sitadhyaksha* was made accountable to collect the good quality seeds and preserve them properly so that these may be made available for agriculturists at the time of sowing.

Kautilya seemed aware of the hurdles in the germination of seeds. He, therefore, suggested that the seeds of cereals and legumes be treated before sowing. He recommended that seeds be exposed to dew in the night and then be dried in sunlight during daytime for five consecutive days for cereals. This practice was to control seedborne fungal diseases; the mycelia might have been activated in the presence of moisture and then killed under hot sun.

Similarly the cut ends of sugarcane sets were plastered with a mixture of honey, ghee (clarified butter), and cow dung. Honey is a good antimicrobial agent and ghee can prevent the sets from contamination by sealing off the cut ends. The loss of moisture through cut ends is also checked by ghee. Cow dung is supposed to be a promoter of biocontrol agents of potential pathogens. The urine content in the cow dung has disinfectant properties.

Cropping pattern

"The *Sitadhyaksha* shall grow wet crops (*kedara*), winter crops (*haimana*), and summer crops (*graishmik*) depending on the supply of water and manpower." These three crop seasons are now called *kharif* (rainy season), *rabi* (postrainy season), and *ziad* (summer), respectively (*kharif, rabi,* and *ziad* are Arabic words).

Kautilya categorized rice as the best crop for cultivation. Vegetable crops were considered intermediate and sugarcane worst because it is difficult to grow and is subjected to various evils (probably pests and diseases). The crop also requires much attention and expenditure to reap. Today we see that the observations made by Kautilya are true.

Regarding other crops he mentioned that banks of rivers are suitable for growing cucurbits (*valliphala*). Lands that are frequently overflown by water are suitable for the cultivation of *Piper longum* (*pippali*; long pepper), grapes, and sugarcane. Vegetable and root crops should

be cultivated near wells, lowlands for green fodder, and borders are used for plantation of fragrant plants, medicinal herbs, *khus* (*Vetiveria zizanioides*; vetiver) etc.

Apart from cropping patterns, Kautilya fixed minimum standard for grain yield and crop yield. He mentioned a number of cultivated crops and the conversion ratio of yield when de-husked or hulled. He also laid down standards of oil extraction yield, the spinning yield of cotton and the byproducts. He gave detailed account of cultivation after classifying the lands and average rainfall in certain regions.

Harvesting

Kautilya described that "Produce shall be collected immediately after harvesting. Nothing should be left in the field, not even chaff. Crops when reaped should be heaped up in high piles giving proper space. Threshing floor of different fields shall be situated close to each other."

Laborers and artisans

Kautilya mentioned that laborers be engaged for different agricultural operations like preparation of field, sowing, irrigation, threshing, and harvesting. Blacksmiths, carpenters, basket sellers, and other such persons must be ready to help the agriculturists. No delay on the part of these persons will be tolerated and a fine equal to the amount of loss be realized from the person or persons at fault.

Kautilya had a great compassion for workers; therefore, it was made mandatory for the landholders to arrange proper facilities for workers. They had to provide drinking water to the laborers on the threshing floor and other working places. He also warned the laborers not to bring any 'fire' (flammable items) on the threshing floor, probably to prevent fire incidents. He made arrangements to provide wages to workers and artisans in proportion to the amount of work done by them.

Animal Husbandry

Use of animals for the welfare of human society has been mentioned in Vedas. Kautilya also knew the importance of animals especially cows and mentioned that the killing of cow is a deadly sin and severe punishment be given to a cow killer. He considered cow as a sacred animal and mentioned in Artha-sastra that the king will visit the cows daily and salute cows with calves and bull by circumambulating around them before going to court. About cows' welfare the following directions were given to the Superintendent of cow:

- While forming village, sufficient suitable land be made available for pasture.
- *Gopas* or village accountants shall note the number and boundaries of the pastures.
- There shall be breeding bull in the herd.
- Herds may move from one pasture to another depending on the season and availability of grass.
- Cows should be guarded behind the walled enclosures.

- The quantity of food should be given in proportion to the quantity of milk yield by cows and duration of work done by bullocks.
- Cow shall be milked twice daily especially during rainy season, autumn, and part of winter, and only once (in the morning) in summer – due to low availability of grass during hot months.
- Cow should be fed with grass and dry straw. (Special recommendations were made about oil cake feed.)

Buffaloes were also used for milk. It was stated that buffalo's milk is richer in butter than cow's milk. The fact has been established very well today.

In addition to the Superintendents of agriculture and cow, Kautilya made separate Superintendents for horses, elephants, forest, wild life, and weaving.

Asses were used for carrying burden and horses for riding and for war. Horse chariots and carriages were used. Royal horses were under the direct supervision of Superintendent who was responsible for registering the breed, age, color, and place of origin. In Artha-sastra, Kautilya states that breeds of Kamboja (in North Afghanistan), Sindhu (territory watered by Sindhu River), Aratta (Punjab), and Vanaya (a country to the Northwest of India) countries were best. The Sindh breed of white horses were considered fast and best. Horses were trained regularly for warfare by trainers. The training included the circular movement, slow movement, jumping, galloping, etc. Magadha was the first state in India which used elephants on large scale in warfare, for traversing forests and marshy areas. Chandragupta Maurya had 9000 elephants in his kingdom.

Rural Development

Kautilya described in detail the rural development starting from the formation of village. According to him the king may send the people of thickly populated city of the kingdom or migrated people, outside the city. Kings should construct villages for these persons either on new sites or old ruins. In this way the population is uniformly distributed because a thickly populated city as we see today becomes unmanageable as far as the facilities to the people are concerned.

"A village will consist not less than one hundred and not more than five hundred families of the cultivators. The village boundary shall be fixed up to one or two *krosa* (one *krosa* = 2 miles) which shall be denoted by a river or mountain, a forest, trees, etc."

Land prepared for cultivation was given to tax payer only up to the life of the person. Lands were taken back from those who did not cultivate but gave to others for cultivation. The cultivators who regularly paid their taxes were entitled to get the supply of grain, cattle, money, etc.

Kautilya's Artha-sastra described the facilities given to spiritual guides, physicians, veterinary surgeon, horse trainers, and messengers. Fertile land was given to such a person without tax but they did not have any right to sell or mortgage the land.

Disputes about fields in the village were settled in a very democratic way. These were decided first by elders of the village or neighborhood. If they had divided opinion, decision was sought from respectable people. If both these methods failed, the holding under dispute was taken in the king's possession.

Taxes

In order to collect revenue for the government Kautilya made provisions of taxes and fines. Tax was imposed on land use but for certain social works provisions were made for tax exemption. In case of new construction work like tanks, lakes, etc., the taxes were remitted for five years. Similarly taxes were remitted on works like repairing of neglected ruins and acquiring uncultivable land for making it cultivable.

Based on the studies of Vedas, Kautilya emphasized strict compliance of the law. Breach of law was taken very seriously and for that he prescribed severe punishment to all. The monetary punishment thus collected was deposited to the government treasury.

Thus the monumental work of Kautilya provided a valuable guidance in the field of agriculture from policy to administration.

How Kautilya's Artha-sastra Came into Light

The text of Artha-sastra by Kautilya was not available until a full text on palm leaves in the *grantha* script, came into the hands of Dr R Shamasastry of Mysore in 1904. Dr Shamasastry published the text in 1909. In 1915 he published the English translation of the text. Since then the Artha-sastra has been translated into many Indian languages, German, and Russian. The treatise has 15 books. In Book 2 of the treatise, Chapter 14 is titled "*Sitadhyaksha*" or the Superintendent of Agriculture.

Questions

1. Superintendent of Agriculture in Kautilya's Artha-sastra is called:
   (i) *Krishiadhyaksha* (ii) *Vartadhyaksha* (iii) *Sitadhyaksha* (iv) *Bhumiadhyaksha*
2. Rainfall was measured in the units of *drona.* One *drona* is equal to:
   (i) 3.2 cm (ii) 5.4 cm (iii) 6.4 cm (iv) 10.4 cm
3. Before planting, cut ends of sugarcane were plastered (dipped) in:
   (i) Cow dung (ii) Ghee (iii) Honey (iv) Mixture of cow dung, ghee, and honey
4. Cows were milked only once during a day in:
   (i) Summer (ii) Rainy season (iii) Autumn (iv) Spring
5. A village will consist about:
   (i) 50 to 200 families (ii) 100 to 200 families (iii) 100 to 500 families (iv) 100 to 800 families

CHAPTER 9

PREDICTION OF MONSOON RAINS

Our ancestors were aware of the fact that life is not possible on this earth without water. They also knew that the main source of water is rain; also agriculture is totally dependent on monsoon rains. The people of ancient India believed that there is some relation between rainfall and heavenly bodies. Therefore, they started to study the heavenly bodies like Sun, Moon, and stars in order to understand the enigmatic pattern of rainfall. This gave birth to the science of Meteorology. Meteorology is generally believed to be a new science. It may be new for the West but not for India, where this science has existed from a very early date. A systematic study of this science was made by our ancient astronomers and astrologers. Observations coupled with experience extending over centuries enabled the great sages of India to develop the subject and to discover the laws governing weather, rainfall, and storms that affect humankind.

Ancient Astronomers

The following ancient sages contributed a lot to our understanding of the planetary position, their movement and their effect on weather pattern.

Aryabhatta

Aryabhatta (499 AD) measured the time period of the movement of different planets and their distance from the Earth. He also documented that the Earth is spherical (Western scientists accepted this fact in 14th century AD) and that it rotates (this was almost 1000 years before Copernicus, the Polish astronomer, 1473–1543 AD).

Parashara

Sage Parashara (c. 400 BC) in his book "Krishi-Parashara" described the techniques of rainfall prediction and measurement, along with agricultural practices for crop production.

Varahamihara

Varahamihara (505–587 AD) studied weather prediction and measurement of rainfall.

Hindu Almanac

Nakshatras

The path of Sun being a fixed circle amongst the stars is called ecliptic. To mark the movement of Sun, Moon, and planets, the ecliptic is divided into 27 equal parts called "*nakshatra*" (constellation) and also 12 equal parts called "*rashis*" (zodiacal signs). The *nakshtras* are:

1. *Ashwini*
2. *Bharani*

3. *Krittika*
4. *Rohini*
5. *Mrigashira*
6. *Aardra*
7. *Punarvasu*
8. *Pushya*
9. *Ashlesha*
10. *Magha*
11. *Purvaphalguni*
12. *Uttaraphalguni*
13. *Hasta*
14. *Chitra*
15. *Swati*
16. *Vishakha*
17. *Anuradha*
18. *Jyeshtha*
19. *Mula*
20. *Purvashadha*
21. *Uttarashadha*
22. *Shravana*
23. *Dhanishtha*
24. *Shatabhisha*
25. *Purvabhadrapada*
26. *Uttarabhadrapada*
27. *Revati*

The Moon takes approximately one day to pass through one *nakshatra* and Sun 13 to 14 days to pass through one *nakshatra*. Each *nakshatra* is divided into four *padas* or *charans*. Nine consecutive *padas* fall in one *rashi*. In the Indian calendar there is a permanent relationship between the solar months, *rashi* division, and *nakshatra* division.

Rashi

The twelve *rashis* which mark the apparent path of Sun are as follows:

1. *Mesha* (Aries)
2. *Vrishabha* (Taurus)
3. *Mithun* (Gemini)
4. *Karka* (Cancer)

5. *Simha* (Leo)
6. *Kanya* (Virgo)
7. *Tula* (Libra)
8. *Vrishchika* (Scorpio)
9. *Dhanu* (Sagittarius)
10. *Makara* (Capricon)
11. *Kumbha* (Aquarius)
12. *Meena* (Pisces)

The Sun takes approximately one month to pass through one *rashi*.

Months

There are twelve months in a year which are as follows:

1. *Chaitra* (April)
2. *Vaishakha* (May)
3. *Jyeshtha* (June)
4. *Aashadha* (July)
5. *Shravana* (August)
6. *Bhadrapada* (September)
7. *Ashwin* (October)
8. *Kartika* (November)
9. *Margashirsha* (December)
10. *Pausha* (January)
11. *Magha* (February)
12. *Phalguna* (March)

Each month is divided into two fortnights called *pakshas*. The *Shukla Paksha* corresponds with the bright fortnight, whereas *Krishna Paksha* corresponds with the dark fortnight.

Seasons

According to Rigveda there are six seasons or *ritus*:

1. *Vasanta* (*Chaitra–Vaishakha* or April–May)
2. *Grishma* (*Jyeshtha–Aashadha* or June–July)
3. *Varsha* (*Shravana–Bhadrapada* or August–September)
4. *Sharat* (*Ashwin–Kartika* or October–November)
5. *Hemanta* (*Margashirsha–Pausha* or December–January)
6. *Shishira* (*Magha–Phalguna* or February–March)

Tithi

Tithi is lunar day. There are thirty *tithis* in all, fifteen in *Shukla Paksha* and fifteen in *Krishna Paksha*. The fifteenth day of the bright half (*Shukla Paksha*) is called *Purnima* or *Puranmashi*, which is considered an auspicious day. The fifteenth day of dark half (*Krishna Paksha*) is called *Amavasya*, which is generally considered as an inauspicious day. The *tithis* are:

1. *Prathma (Pratipada)*
2. *Dwitiya*
3. *Tritiya*
4. *Chaturthi*
5. *Panchami*
6. *Shashthi*
7. *Saptami*
8. *Ashtami*
9. *Navami*
10. *Dashami*
11. *Ekadashi*
12. *Dwadashi*
13. *Triodashi*
14. *Chaturdashi*
15. *Purnima/Amavasya*

Var

There are seven *vars* (days) in a week. These *vars* are *Ravivar* (Sunday), *Somvar* (Monday), *Mangalvar* (Tuesday), *Budhvar* (Wednesday), *Brahaspativar* or *Guruvar* (Thursday), *Shukravar* (Friday), and *Shanivar* (Saturday) named after the Sun, Moon, and five planets Mars, Mercury, Jupiter, Venus, and Saturn, respectively.

Yog

The time during which joint motion of the Sun and Moon covers the space of a *nakshatra* is called *yog*. Therefore, there are 27 *yogs* for 27 *nakshatras*.

Karn

Half of the lunar day is called *karn*. Depending on the lunar motion, the duration of a particular *tithi* is reduced to half (*karn*) or may be more than a day.

Nadi

For predicting the monsoon and its subsequent effect on weather, all *Panchanga* makers consider three *Nadi-Siddhanta* (capsular theories), commonly known as *Nadi-Chakra*.

1. *Dwinadi-Chakra*
2. *Trinadi-Chakra*
3. *Saptanadi-Chakra*

All the *nakashatras* are grouped in two categories in *Dwinadi-Chakra* whereas in *Trinadi-Chakra* these *nakshatras* are grouped in three categories. In *Saptanadi-Chakra* all the *nakshatras* are grouped in seven categories. The prediction of rainfall is done only on the basis of *Saptanadi-Chakra*. The seven *nadis* of *Saptanadi-Chakra* are:

1. *Chandra*
2. *Vata*
3. *Vanahi*
4. *Neera*
5. *Somya*
6. *Jala*
7. *Amrita*

The *Saptanadi-Chakra* and its effect on weather are given in Table 1.

Table 1. Arrangement of *nakshatras* in *Saptanadi-Chakra* and their effect on weather.

Arrangement of *nakshatras*			*Nadi*	Effect on weather
2 *Bharani*	17 *Anuradha*	16 *Vishakha*	3 *Krittika*	*Chandra*	Bright, sunshine, no rainfall
1 *Ashwini*	18 *Jyeshtha*	15 *Swati*	4 *Rohini*	*Vata*	Sunshine and wind, normal rainfall
27 *Revati*	19 *Mula*	14 *Chitra*	5 *Mrigashira*	*Vanahi*	Strong hot winds
26 *Uttarabhadrapada*	20 *Purvashadha*	13 *Hasta*	6 *Aardra*	*Somya*	Normal rainfall
25 *Purvabhadrapada*	21 *Uttarashadha*	12 *Uttaraphalguni*	7 *Punarvasu*	*Neera*	Very good rainfall
24 *Shatabhisha*	21 *Uttarashadha*	11 *Purvaphalguni*	8 *Pushya*	*Jala*	Abundant rainfall
23 *Dhanishtha*	22 *Shravana*	10 *Magha*	9 *Ashlesha*	*Amrita*	Heavy to very heavy rainfall causing flood

Two "movements" of the Sun

The equator divides the Earth into two equal parts – North and South. The apparent movement (*Ayan*) of the Sun takes place north- and southwards, each time crossing the equator. On 22nd June the Sun begins to move from North to South (*Dakshinayan*) and from 22nd December it starts moving from South to North (*Uttarayan*). When the Sun moves from North to South, the temperature begins to fall in northern hemisphere. When the Sun moves from South to North, the temperature begins to rise. This movement has close relation with weather cycle or "*Rituchakra*".

Effect of Planets on Weather

The heat energy received from the Sun evaporates water in the ocean resulting in cloud formation. Because of the difference of the temperature between land surface and ocean, air movement takes place and the clouds move towards the land surface and vice versa. The gravitational force applied by the Moon on the water mass of the Earth gives high and low tides depending on the phases of the Moon. The force of attraction is also applied by other planets on the water mass of the Earth. The resultant force acting on the Earth's surface depends on the position of planets on a particular day. Therefore, the occurrence and withdrawal of monsoon are greatly affected by the relative position of Sun and other planets.

Ancient Methods of Weather Forecast

The ancient methods of weather forecast can be classified into two categories:

1. Analytical Methods
- Study of the solar system
- Positions of the planets and Stars
- Study of *Nakshatra-Chakra*
- Study of *Nadi-Chakra*
2. Observational Methods
- Atmospheric changes
- Cloud forms and other sky features
- Physical changes
- Chemical changes
- Bio-indicators

The detailed description of all these methods will form a voluminous book. A few important methods suggested by the ancient sages/scholars for the prediction of rainfall are, therefore, briefly described here.

Parashara technique

The technique given by Sage Parashara on rainfall prediction is mainly based on the position of the Sun, Moon, and other planets. According to Parashara, every year has a "ruler planet"

and "minister planet" along with a particular cloud which are responsible for rains. The method of finding "ruler planet" of the year was given by Parashara and was adopted later. It is as follows:

Multiply the number denoting *Saka* year by three. Add two. Divide the result by seven. The remainder is the number indicating the "ruler planet" of the *Saka* year. The planet which is fifth from the "ruler planet" indicates the "minister planet" of the year.

For example: Let us find out the "ruler planet" and "minister planet" for *Saka* year 1930 (2008 AD).

$1930 \times 3 = 5790$

$5790 + 2 = 5792$

$5792 \div 7 = 872 +$ remainder 3

The main planets are listed in the following manner:

(1) Sun, (2) Moon, (3) Mars, (4) Mercury, (5) Jupiter, (6) Venus, and (7) Saturn.

As per above calculations Mars is in 3rd position. Hence Mars will be the "ruler planet" for the *Saka* year 1930, corresponding to 2008 of the Julian calendar year. The "minister planet" will be Sun. The effect of these planets on rainfall and other events is given in Table 2.

Table 2. Effect of Sun, Moon, and other planets as "ruler planets" on rainfall and other events during the year.

Ruler planet	Effect
1. Sun	– Average rainfall
	– Diseases of the eye, threat of fever, and all sorts of other calamities, and continuous blowing of winds
2. Moon	– Heavy rains
	– Enrichment of earth with good harvest and health of humankind
3. Mars	– Scanty rains
	– Damage is caused to the crops and the diseases spread among the people and loss of life
4. Mercury	– Good rain
	– Earth free of diseases
	– Plenty of harvest and Earth is blessed with all varieties of crops
5. Jupiter	– Rainfall satisfactory or good
	– *Dharma* prevails on Earth
	– Peace and prosperity
6. Venus	– Prosperity by good rains
	– Enough food grains
7. Saturn	– Rains scanty; wind continuous
	– Outbreak of diseases
	– Wars

The experts should predict rainfall with reference to the "minister planet" of the respective year in the same manner as has been stated above with reference to the "ruler planet" of the year. Thus the net result would be the combined effect of the "ruler planet" and "minister planet".

The method of ascertaining the type of the cloud in the year is given below:

Add 3 to the number of the year. Divide the sum by 4. The remainder indicates the type of cloud. For example, for the *Saka* year 1930 (2008 AD):

$1930 + 3 = 1933$

$1933 \div 4 = 483 +$ remainder 1

The clouds described are:

(1) *Aavarta*, (2) *Samvarta*, (3) *Pushkara*, and (4) *Drona*.

Thus the cloud of *Saka* year 1930 would be *Aavarta*. The cloud *Aavarta* rains in some parts while *Samvarta* rains everywhere. Rainfall is scanty when *Pushkara* is the cloud of the year but *Drona* makes the Earth full of water.

In addition Parashara has given month-wise prediction of rainfall in verses 30 to 64 in "Krishi-Parashara".

Varahamihira technique

Varahamihira (505–587 AD) suggested that after the occurrence of the full moon day of the month of *Jyeshtha* (approximately coinciding with June), the *nakshatra* on which the first rainfall of that year's rainy season is received should be noted. The prediction of rainfall is made on the basis of *nakshatra* on the first day of rainfall. Varahamihira, however, did not mention the amount of rainfall received on the first day. In modern meteorology a rainfall of 2.5 mm or more may be taken as rainy day. Varahamihira's technique for forecasting seasonal rains is given in Table 3.

This method of predicting rainfall was possibly developed by Varahamihira for the city Avantika (modern Ujjain) and its neighborhood area extending up to approximately 80 km from the center of the city. Varahamihira or his disciples perhaps did not try to extend this method to an area larger than the city and its neighborhood. In spite of this, full credit should be given to Varahamihira who became the first full-fledged meteorologist in the history of India.

Prediction based on planets

The atmosphere and rainfall on earth surface is affected by position of planets and *nakshatra*. All the *nakshatras* have been divided into three groups: (1) Masculine, (2) Feminine, and (3) Neutral. The *nakshatras Ashwini, Krittika, Rohini, Purvabhadrapada, Uttarabhadrapada, Anuradha, Shravana, Punarvasu,* and *Pushya* are masculine. *Bharani, Hasta, Chitra, Swati, Vishakha, Purvaphalguni, Uttaraphalguni, Ashlesha, Magha, Jyeshtha, Aardra, Dhanishtha, Purvashadha, Uttarashadha,* and *Revati* are feminine. *Shatabhisha, Mula,* and *Mrigashira* are neutral.

Table 3. Varahamihira's technique for forecasting seasonal rains.

Lunar mansion[1]	Zodaic sign		Predicted total rainfall	
	Sanskrit	English	In ancient units (*dronas*)[2]	In modern units (cm)
Hasta	*Kanya*	Virgo	16	102.4
Purvashadha	*Dhanu*	Sagittarius	16	102.4
Mrigashira	*Vrishabha*	Taurus	16	102.4
Chitra	*Kanya*	Virgo	16	102.4
Revati	*Meena*	Pisces	16	102.4
Dhanishtha	*Makara*	Capricorn	16	102.4
Shatabhisha	*Kumbha*	Aquarius	4	25.6
Jyeshtha	*Vrishchika*	Scorpio	4	25.6
Swati	*Tula*	Libra	4	25.6
Krittika	*Vrishabha*	Taurus	10	64.0
Shravana	*Makara*	Capricorn	14	89.6
Magha	*Simha*	Leo	14	89.6
Anuradha	*Vrishchika*	Scorpio	14	89.6
Bharani	*Mesha*	Aries	14	89.6
Mula	*Dhanu*	Sagittarius	14	89.6
Purvaphalguni	*Simha*	Leo	25	160.0
Punarvasu	*Mithun*	Gemini	20	128.0
Vishakha	*Vrishchika*	Scorpio	20	128.0
Uttarashadha	*Makara*	Capricorn	20	128.0
Ashlesha	*Karka*	Cancer	13	83.2
Uttarabhadrapada	*Meena*	Pisces	25	160.0
Uttaraphalguni	*Kanya*	Virgo	25	160.0
Rohini	*Vrishabha*	Taurus	25	160.0
Purvabhadrapada	*Kumbha*	Aquarius	15	96.0
Pushya	*Karka*	Cancer	15	96.0
Ashwini	*Mesha*	Aries	12	76.8
Aardra	*Mithun*	Gemini	18	115.2

1. On the day of the first rainfall of the season.
2. 1 *drona* = 6.4 cm.

When the Sun and Moon are in the neutral *nakshatras*, there will be winds. When they are in feminine *nakshatras*, there will be lightning. When the Sun occupies a feminine *nakshatra*, and the Moon is in a masculine *nakshatra* or vice versa there will be rains.

In addition predictions are made by seeing the positions of Sun, Moon, planets, and *nakshatras*. Amongst several combinations used for rainfall prediction, only ten are given below as examples:

1. When the Sun is in between Venus and Mercury, there is break in monsoon, i.e., for some days there will be dry spell.

2. When Sun is behind Mars in rainy season, there will be poor rains or rain is delayed or there will be dry spell.
3. When Sun is overtaking Mars in rainy season, there will be heavy downpour of rains causing flood in rivers.
4. When the Moon is in the 5th, 7th, or 9th house from Saturn, there will be immediate rains.
5. When Venus is in *Swati, Vishakha*, or *Anuradha nakshatra*, rainfall is unpredictable.
6. When Venus is in *Magha* or *Uttarashadha*, there will be drought conditions.
7. When Venus is in one of the *nakshatras*, i.e., *Jyeshtha, Mula, Purvashadha, Uttarashadha*, and *Shravana*, there will be famine for want of rains.
8. When Mars and Saturn are in conjunction, rainfall will be very low.
9. When Sun, Mars, and Venus transit the same *rashi*, rainfall is disturbed.
10. When Jupiter retrogrades in *Rohini*, the year will have less rainfall.

Bio-indicators

By observing activities of birds and other animals, the farmers of India have been predicting the weather. For example, if the common bird myna bathes in the water, rainfall is expected in one or two days. Few examples are given in Table 4.

Apart from the activities of the animals ancient farmers were also familiar with plant indicators. The *amaltas* (*Cassia fistula*) tree is a unique indicator of rain. It bears bunches of golden yellow flowers in abundance about 45 days before the onset of monsoon. This has been verified by the scientists by assessing the rainfall and date of flowering of *amaltas* from 1996 to 2001 AD (Table 5).

Other ancient rainfall predictions

Some other ancient rainfall predictions are:

- If the spectrum around the Sun had a greater diameter than that around the Moon, then rain is expected after one or two days.
- If there is an accumulation of clouds in the Southeast direction in a layered form accompanied by winds blowing from the southern direction, then it is claimed that there will be rainfall within a day or two.

Folklore Regarding Weather Forecasting

Ghagh and his wife Bhaddri (c. 1300 AD) have composed poems relating to weather forecasting. Some of these are still very popular in northern India and are given below:

- When it is very hot during the day and there is dew at night then there are very limited chances of rainfall.
- When strong eastern winds blow continuously, then it is estimated that the rainy season has come.

Table 4. Behavior of birds and animals as predictors of rain.

Indicator	Expected outcome
Sparrow bathing in dust	Good rain
Chameleon climbs the tree and assumes black, white, or red color	Immediate rain
Frogs start singing in initial days of *Jyeshtha* (June)	Early rain
Bater (common quail) sings in pairs	Certainty of rain
Peacocks cry frequently	Rain within a day or two
Cows moo during night and foxes during the day	Severe drought
Titodi (lapwing) lays eggs during night, espcially on riner banks	Heavy rain
Papiha (common hawk-cuckoo; *Cuculus varius*) sings early in the morning; snake climbs on the tree	Rain within a day or two
Camel keeps facing northeast direction; goat does not browse; crow scratches its nest	Immediate rain
Birds bathe in dust on the full moon day of *Jyeshtha* (June)	Plenty of rains

Table 5. Flowering of *amaltas* tree and onset of monsoon.

Assessment year	Date of flowering in *amaltas*	Predicted date of onset of monsoon[1]	Actual date of onset of monsoon
1996	29 April	13 June	14 June
1997	20 April	4 June	1 June
1998	22 April	6 June	9 June
1999	30 April	14 June	17 June
2000	26 April	10 June	8 June
2001	29 April	3 June	14 June

1. Forty-five days after flowering.

- When a rainbow is formed in the direction of Bengal (southeast from Uttar Pradesh) then there will be rainfall.

Rainfall in Northwestern part of Rajasthan has always been erratic, sporadic, and uncertain. Farmers of desert used to predict weather on the basis of certain plants and animals found there. These observations are transferred from one generation to another orally by means of poems or songs in their local language. For example:

"Rata bole kagla, din ma bole siyal
Ke dharti ro dhani mare, ke pher pade akal."

It means that if a jackal's voice is heard during daytime particularly before sunset and crow caws at night then there are chances of famine for want of rains and death of some top landlord.

In southeast Rajasthan where farmers grow maize and paddy, the tribal farmers predict rainfall by keeping a twig of *giloe* (*Tinospora* sp.) on the roof of the house before the onset of monsoon. If the twig remains viable and sprouting of roots occurs in the twig then this is an indication of rainfall which would be sufficient for rice cultivation. Appearance of fewer roots is the indication of rainfall suitable for maize cultivation.

Meghamuni who lived in Phagwara of Punjab was a famous Ayurvedic physician, astrologer, and a researcher in weather forecasting. His book "Meghamala" consists of a number of verses popularly known as '*dohra*' on the prediction of rainfall and crop condition for the twelve months right from *Kartika* (November) to *Ashwin* (October). Some of the predictions of rainfall are given below:

- If there are clouds on the 12th day of bright half (*Shukla Paksha*) of *Kartika* (November), then during *Aashadha* (July) there will be enough rainfall.
- Thundering clouds, lightning, and eastern winds in the month of *Pausha* (January) are indications of good rains in the month of *Shravana* (August).
- Excessive hot winds in the month of *Jyeshtha* (June) is an indication of heavy rains during monsoon months.
- In the month of *Jyeshtha* (June), if the first lunar day of dark fortnight (*Krishna Paksha*) falls on Thursday, Saturday, or Friday, then there will be plenty of rains.

"*Panchanga*" or Almanac

The word "*Panchanga*" is made by the combination of two words "*panch*" (means "five") and "*anga*" (means "parts"). These five parts are *tithi, var, nakshatra, yog*, and *karn*. The "*Panchanga*" or Almanac has an important place in the Indian Society. It is the book which is used for making astrological calculations, for reading horoscopes to find auspicious time or day for social and agricultural activities, and for making predictions. Several *Panchangas* are now available region-wise; some important ones are:

- *Drik-siddha Panchanga*
- *Sri Ganesh Panchanga*
- *Hrishikesh Panchanga*
- *Vishnu Panchanga*
- *Date Panchaga*
- *Goverment of India Panchanga*

Researchers have revealed that rainfall predictions made in *Panchangas* based on ancient astrological theories are better or in few cases similar to the predictions made by India Meteorological Department through modern techniques and procedures.

Looking at the accuracy and correctness of rainfall prediction made in *Panchangas*, the scholars are now engaged in the preparation of region-wise "*Krishi-Panchanga*" for the predictions exclusively related to agriculture, giving information on various aspects of rainfall, auspicious and inauspicious time for undertaking or avoiding various agricultural activities along with the time and date for observing religious rites, festivals, and fasts. "*Krishi-Panchanga*" would be very useful for farming communities.

Using traditional methods, a *Panchanga* called "*Nakshatra Varsha*" has now been designed for the use of farmers to predict rainfall distribution. By this *Panchanga*, the rain distribution can be predicted about 6 weeks in advance of sowing. "*Nakshatra Varsha*" has been found very useful in Maharashtra.

In the past our ancient sages had developed a concept of prediction of weather and crop production using the movement of planets in relation to Earth which was presented in the form of *Panchanga*. The modern scientific approach was developed in the end of 19th century for the prediction of weather. After about 100 years there seems no significant improvement in the modern scientific approach although a slow success rate is visible. This is mainly because the modern scientific models are not process-based but mostly empirical-statistically based. Therefore, the future modern forecasts must look at process-based concept by including past knowledge coupled with the changes introduced by man's action on the environment.

Questions

1. World's first attempt to use knowledge of Astronomy in predicting rains was made in:
   (i) China (ii) Egypt (iii) India (iv) Greece
2. That the earth is sperical and rotates around Sun was first documented by:
   (i) Copernicus (ii) Parashara (iii) Aryabhatta (iv)Varahamihira
3. Which of the following is/are *nakshatra(s)* (constellations)?
   (i) *Mrigashira* (ii) *Hasta* (iii) *Revati* (iv) *Mesha*
4. Which of the following sages or scholars developed "models" for predicting monsoon rainfall?
   (j) Varahamihira (ii) Parashara (iii) Kashyapa (iv) Kautilya
5. Folklore on weather forecasting of which of the following poets are popular in North India?
   (i) Ghagh (ii) Bhaddri (iii) Meghamuni (iv) Kalidasa

CHAPTER 10

SOIL CLASSIFICATION AND MANAGEMENT

Soil is generally defined as the upper layer of the earth in which plants grow. Soil has been regarded, since time immemorial, as a source of nourishment to all animates, moving or static. In Vedas soil has been described as the "Mother" and human beings as her sons. "Mother Earth" referred to as soil which is rich in energy was thought to be activated by *Parjanya* (cloud) and *Dyus* or the Sun. In Atharvaveda, soil has been described as:

- Something in which the vegetation and agricultural crops grow and ripen;
- Something upon which all the living beings are nourished; and
- Something which provides man plenty of enjoyment.

From agricultural point of view, soil is loose earth surface that supports vegetation, its quality, type, and density. From time immemorial the farmers of India have treated soil as a living entity and even today they believe that continuous cultivation of soil makes crop-bearing capacity of the soil feeble, which then requires 'rest' to rejuvenate its quality. *Jhum* or shifting cultivation is an example of this faith.

Kashyapa (c. 800 AD) in his treatise "Kashyapiyakrishisukti" stated:

- Soil should have the substantial mass, devoid of bones and stones.
- Soil should consist of clay with reddish and black hue.
- Soil should not be too deep or shallow.
- Soil should be conducive to speedy seeding and emergence.
- Soil should be easy for plowing.
- Soil should be capable of absorbing moisture easily.
- Soil should be inhabited by beneficial living organisms.

Thus we see that much before the advent of modern science, the value of the soil's capacity to fulfill the basic needs of man was fully understood by Indians.

Soil not only serves agriculture and forestry but also is highly helpful in filtering, buffering, and transformation activities between the atmosphere and the groundwater, protecting the food chain and drinking water from pollution, and broadening biodiversity.

Soil Classification

Classification based on soil fertility and color

In ancient India soil was classified based on its crop yielding ability and color. Based on crop yielding capacity the soils were categorized into three types.

1. *Urvara* (fertile)
2. *Usara* (non-fertile, saline, etc.)
3. *Maru* (desert)

Based on color the soil was classified as given below:

1. *Bhabhru* – soil of brownish color with intensive bearing capacity.
2. *Krishna* – soil of black color and plowable.
3. *Rohini* – soil of reddish color and capable of growing any vegetation.

Classification based on climate

Climate is an important element of soil formation. Hence in ancient times the soils were classified on the basis of climate as given below:

1. *Jangla* (barren) – soils belonging to dry regions characterized by open space, presenting a flat surface with scanty growth of thorny bushes and exposed to regular invasion of desiccating winds.
2. *Anupa* (moist) – marshy or swampy region abounding in rivers and bordered by sea, and swept by winds, i.e., charged with abundant moisture.
3. *Sadharana* (ordinary) – soils of the regions supporting common plants and vegetation.

Many aspects of the ancient climate-based classification have parallels in the modern Soil Taxonomy. For example, the Aridisols of today correspond to *Jangla*. Likewise soils of adequate moisture regime are akin to *Anupa.*

Classification based on topography

During the medieval period the Indian soils were classified on the basis of texture, slope, and crop suitability as given below:

1. *Matasi* – yellow soils on flat topography; loam, and loamy clay, good for rice cultivation.
2. *Dorsa* – dark soils on the slopes, rest like *Matasi.*
3. *Kanhar* – dark and slightly heavier than *Matasi* or *Dorsa* in lowlands, good for rice and wheat cultivation.
4. *Bhata* – barren wastelands as upland with gravelly sand, reddish yellow in color.

Classification based on revenue

When foreign invaders ruled India, revenue collection was the basis of soil/land description. More revenue was levied on irrigated than on rainfed lands. The Mughals during 1570 AD evolved the following classification for the purpose of levying revenue.

1. *Khalsa* – primary revenue yielding land.
2. *Jagir* – land enjoyed by the noble people, who collected revenue from the actual cultivators and out of which they sent a portion to the Emperor and kept the rest for themselves.
3. *Sayurghal* – land granted for cultivation on free tenure.

Actually the above classification was for land rather than soil, probably because the Mughals considered soil and land as the same entity. Later in 1582 AD, Todar Mal[1], the Revenue Minister of Akbar, classified the land as follows:

1. *Polaj* land, which is annually cultivated for each crop in succession and is never allowed to lie fallow.
2. *Parnauti* land, which is left out of cultivation for sometime so that it may recover strength (seasonal fallow).
3. *Chachar* land, which is kept fallow for 3 to 4 years (temporary fallow).
4. *Banjar* land, which remains uncultivated for 5 years or more.

Classification in pre-modern period

In the pre-modern period the system of classification essentially centered on the following:

1. Economic classification – based on crop and irrigation; for example, forest soils and irrigated soils. This classification lost its relevance with the change in the land use system.
2. Physical classification – based on the texture of the soil particles; for example, *khaddar* soils and gravelly soils.
3. Chemical classification – based on some chemical properties such as the presence of lime, gypsum, and salt or high or low pH; for example, saline soils and alkaline soils.
4. Geological classification – based primarily on the mode of material transport. For example, alluvial soils (water borne) and aeolian soils (wind transport).
5. Physiographic classification – based mainly on landscape characteristics; for example, basin soils, hill soils, upland soils, and lowland soils.

Classification in 20th century

In the beginning of the 20th century JW Leather, the first Imperial Chemist of Agricultural Research Institute, Pusa, Bihar developed an indigenous method of characterizing the Indian soils, placing them in four broad groups:

1. Indo-Gangetic alluvial soils
2. Black soils
3. Red soils
4. Laterite and lateritic soils

This system was subsequently refined and developed further and included eight soil groups.

1. Raja Todar Mal introduced standard weights and measures, a land survey and settlement system, and revenue districts and officers. He was apparently the first statistician of India and perhaps of the world. Many of the fundamental data collection schemes as practiced over centuries in the Indian subcontinent and the neighboring countries can be attributed to him.

1. Alluvial soils
2. Black soils
3. Red soils
4. Laterite or lateritic soils
5. Forest soils
6. Desert soils
7. Saline and alkaline soils
8. Peaty soils

Soil Management

Soil management has an important role in boosting up the agricultural production. In India, the ancient farmers had the knowledge about land preparation, rainfall prediction and its measurement, and fertilization, which are important components for the management of the soil.

Land preparation

In Vedas it has been described that whatever may be the type of land, whether low-lying, high, middle mountains, sandy, gravel, or fertile, it is the preparation of the land that gives the crop yield. The well managed soil by good preparation was called "Gold-bearing" soil. During this period soil management was based on area-extensive practices. Land clearing, shaping, fallowing, shifting cultivation, and choice of individual crop were the main strategies of soil management.

Rainfall

Rain, especially in rainfed areas, is the key element determining the soil management practices. Since germination after seeding and subsequent growth depends upon moisture availability, prediction of rainfall constitutes an important aspect of overall agricultural management.

As early as 400 BC a system of prediction of rainfall was given by Parashara. A verse from "Krishi-Parashara" also states that rain is essential for life, so one should first acquire carefully the knowledge about rainfall. The Indian system of rainfall prediction is based on the position of Sun and Moon combined with the type of clouds and *nakshatra* (constellation) in the ensuing season. Based on the prediction of rainfall, farmers used to select appropriate time for sowing the seeds.

Fertilization

The Indian farmers of the ancient times knew the value of organic manures for soil management. There is a Telugu proverb: "A soil without manure is as barren as is cow without calf." Similarly, another ancient saying states: "No fodder, no cow; no cow, no manure; no manure, no crop."

In the medieval period, farmers applied organic manures as used by the farmers of ancient time for sustainable crop production. The farmers not only used animal wastes as manure but also had deep knowledge on the use of green plants and other residues for getting good yields.

The liquid manure *Kunapajala* was described by Surapala about 1000 years ago. The *Kunapajala* of Surapala was actually the fermented product of animal flesh, bones, brain, blood, etc. These materials were mixed with water and allowed to ferment underground for 1–3 months.

In 1025 AD, Chavundaraya also suggested the use of *Kunapajala* for improving tree growth, flowering, and fruiting.

During Mughal period, two crops, *Dolichos uniflorus* (*kulthi*) and *Crotalaria juncea* (sunnhemp), were grown widely to sustain soil fertility. The decay of their roots, stem, and leaves make the surface soil richer in organic matter and nitrogen. It means that the beneficial effects of legumes in maintaining soil fertility were known to the farmers of India.

A treatise "Nuskha Dar Fanni-Falahat" written by Dara Shikoh (17th century) mentions the use of niter (sodium nitrate), an inorganic nutrient as fertilizer. Crop specific manure combinations and their method of application had been given. For example, dung, salt, and niter were suggested for soil application in case of palm tree.

In modern agriculture the use of inorganic fertilizer enhanced with the introduction of high-yielding varieties and irrigation facilities. Now we see that the use of these fertilizers has increased about 300 times since the independence. The fertilizers have created the problem of pollution. The nitrous oxide produced from de-nitrification of nitrogenous fertilizers pollutes the environment, and nitrate pollutes the drinking water. The adverse effects of the overuse of fertilizers cast doubts on the sustainable development of agriculture.

Questions

1. Soil was classified into 3 types, viz., *Bhabru*, *Krishna*, and *Rohini*. The basis of this classification was:
   (i) Fertility (ii) Water absorbing ability (iii) Taste (iv) Color
2. Revenue-based soil classification was first made by:
   (i) Leather (ii) Kautilya (iii) Birbal (iv) Todar Mal
3. The first documentation of the use of inorganic fertilizer (niter) was made by:
   (i) Parashara (ii) Kashyapa (iii) Surapala (iv) Dara Shikoh
4. Soil was first described as "mother" in:
   (i) Vedas (ii) Puranas (iii) Upanishads (iv) Artha-sastra
5. Grouping of soil into Alluvial, Black, Red, and Lateritic was done by:
   (i) JW Leather (ii) EJ Butler (iii) JS Kanwar (iv) Albert Howard

CHAPTER 11

AGRICULTURAL IMPLEMENTS

The Plow and Importance of Plowing

The Sanskrit word *krshi* denotes agriculture. "*Krshi*" means the act of plowing. Hence, the selection of suitable land/soil and its preparation by plowing before sowing are very essential and our forefathers had given great attention to these aspects. Agricultural operations carried out in those days are summed up in ancient texts as plowing, sowing, reaping, and threshing. The bullocks and the plow were the most necessary accessories for cultivation. In some places horses and camels also have been used to plow the field.

The plow was considered the most sacred and an essential implement in agricultural operations and was known by different names such as *hala*, *sira*, *langala*, and *sita* (Fig. 1). Kings like Janaka (of Ramayana) plowed the fields themselves. Balarama (Krishna's brother) used to carry the plow on his shoulder and was known by the name *Haladhara*. Since it was necessary to remove weeds, thorny shrubs, stones, and other undesirable objects before actual sowing, the special plow known as *langala* was used extensively, drawn by more than a pair of bullocks. Repeated plowing was done to enable the soil to get the required tilth. The custom to plow the field over and over again from one end to the other and in reverse direction was in vogue to make cultivation more fruitful and intensive. Amarkosha (lexicon of Amarsimha) refers to the land twice plowed as *dwigunakritam,* thrice plowed as *trihalyam* or *trisityam,* and plowed after sowing as *vijakritam* or *prakrishtam.*

It was believed to be highly meritorious to gift a plow. Stealing or misappropriating plows was heavily punishable and more so, if it was done

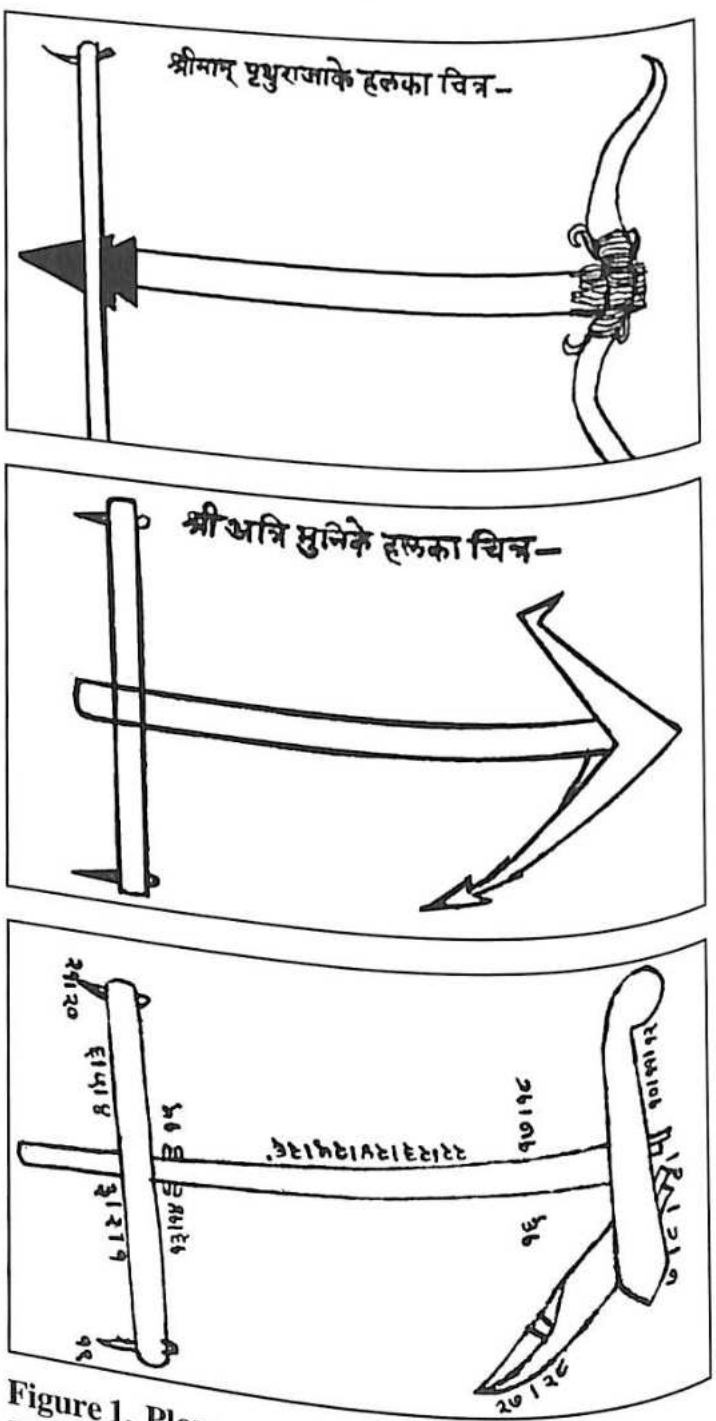


Figure 1. Plows used in ancient India: (top) by King Pruthu; (middle) by Sage Atri; (bottom) another type.

in the season of plowing. The king was to determine the punishment after considering the time and compulsion of offense.

Sira (plow) is mentioned in the Rigveda and often in later literature. *Sira* was a large and heavy plow, requiring six or eight or twelve or even twenty-four oxen to drag it. The oxen were yoked and harnessed with traces. The oxen were guided by the *astra* or goad (driving stick) of the plowman. Little is known about the parts of the plow used during the period of Rigveda. While plowing the field, due care of oxen was taken. Two verses in Rigveda are very meaningful.

"May the oxen draw happily, the men labour happily, the ploughs furrow happily; may the braces bind happily, wield the goad happily."

"May the ploughshares break up our land happily; may the plough go happily with the oxen; may *Parjanya* (rain) shower the earth with sweet water."

In contrast to the Vedic and other ancient literature, we find some verses about the sensitivity of the earth to the operation of plowing. This is illustrated in the following verse:

"People think agriculture to be good; but that occupation is despised by the righteous; the iron-tipped wood injures the earth and the earthly creatures." (Manusmriti, c. 200 BC)

A simple test to check the fertility of land and its suitability for cultivation was as follows:

"Get the land ploughed and sown with some seeds; if the seeds sprout and become big in three, five, or seven days, the land should be known to be the best; if the sprouts are small, that land is to be avoided; if the sprouts are tolerably high that land is middling." (Matsya Purana, Chapter 253, *slokas* 17 and 18)

Parts of the plow

Krsi-samgraha, also sometimes known as Krishi-Parashara, is a text solely devoted to the science of agriculture. Parashara lived around 4th century BC. Krishi-Parashara gives elaborate description of the constituent parts of the plow (Fig. 2).

The plow consists essentially of the following eight parts: *isa* (beam), *yuga* (yoke), *niryola* (rod of the plow excluding the pole and the share), *niryolapasika* (iron plates that fix the share to the *niryola;* there are two pairs of *pasika*), *halasthanu* (a strong piece of wood that is fixed to the *niryola* at the end opposite to where the plowshare is fixed; this is held by the cultivator while plowing the field), *addacalla* (pins of the yoke where the bullocks are tied), *saula* (the plowshare consisting of an iron blade which digs up mud), and *paccani* (goad).

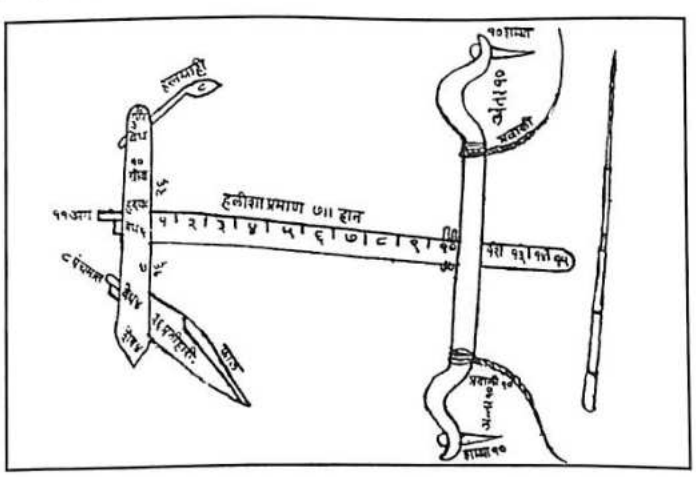


Figure 2. Plow described by Parashara showing *pratoda* (goad).

The measurement of these parts is also mentioned by Parashara. The *isa* (beam) should be 5 cubits long (1 cubit = 1 'hand', i.e., the length from elbow to the tip of the middle finger), *sthanu* (post) 2½ cubits, *niryola* 1½ cubits, *yuga* (yoke) should extend to the ear of the animal, *niryolapasika* and *addacalla* 12 *angulas* (nine inches), *saula* nearly a cubit, and *paccani* should be about 12 or 9 *mustis* (about 4½ or 3 feet long) and made of strong bamboo with an iron end. *Abandha* (the string which binds the yoke to the beam) should be about 15 fingers (one foot) long and cylindrical in shape, *rajju* (rope) 5 cubits long, *yoktra* (to tie the yoke) 4 cubits in length, *phala* (the plowshare) one cubit and 5 *angulas*, and *pasika* should be nine *angulas* (about seven inches) and appear like a leaf of *arka* (*Calotropis gigantea*). *Pratihari* (where the plowshare is fixed) should be 36 *angulas* (27 inches) long, which would bring the stones, weeds, roots of shrubs, etc. buried in the soil to the surface.

It was advised that the wood of the trees producing milky sap such as pipal or *asvattha* (*Ficus religiosa*), *nyagrodha* (*Ficus benghalensis*), *gular* (*Ficus glomerata*), *pakar* (*Ficus rumphii*), *bilva* (*Aegle marmelos*), neem (*Azadirachta indica*), and *vibhitaka* (*Terminalia bellirica*) should not be used for the construction of the plow. The common characteristic of all these species is that the timber is not hard. The *halisha* (beam) should be made of a strong wooden pole 7½ cubits in length of sal (*Shorea robusta*) and it should be round and not conical. The *yuga* (yoke) should be four cubits long and made of the wood of *kadamba* (*Anthocephalus cadamba*), *sara* (*Cupressus sempervirens*), and *medhasingi* (*Gymnema sylvestre*). It should have the shape of second day of moon, so that it would not cause any wound on the shoulder of the bullock.

Rules for plowing

Sage Parashara set the rules for plowing in the field and stated that to increase the yield of crops, the farmer should plow on Monday, Wednesday, Thursday, and Friday and during the periods of lunar mansions: *Mrigashira, Punarvasu, Uttaraphalguni, Hasta, Swati, Uttarashadha, Uttarabhadrapada* and also *Pushya, Mula*, and *Shravana*. The cultivation commenced on Tuesday, Sunday, or Saturday causes disturbance in the country. The second, third, fifth, seventh, tenth, eleventh, and thirteenth days of a bright fortnight are auspicious for plowing. If plowing is commenced on the first day of a bright fortnight, there occurs loss of crops, and so on. Though farmers still follow some of the suggestions, there is no scientific evidence to support these suggestions.

The bullocks that are black, or red, or partly black and partly red are auspicious for agricultural operations. A healthy farmer should plow with healthy bullocks only.

Sage Parashara admonishes farmers to plow uninterruptedly, lest the furrows be discontinuous. He said that the field should be plowed once, thrice, and five times successively. Plowing the field once brings success; thrice gives yield of necessary crops; while plowing five times in succession produces plenty of crops. If the plowing is performed in the month of *Magha* (February) the earth's produce is valued like gold; if in *Phalguna* (March) like silver; if in

Chaitra (April) like copper; if in *Vaishakha* (May) as paddy; in *Jyeshtha* (June) like dust; in *Aashadha* (July) like mud; while in *Shravana* (August), the earth does not bear any crop at all.

The wooden plow appears to have retained its form since the Vedic times with minor modifications in its parts according to the needs of the farmers of different states (Fig. 3). The essential part is the plowshare, which still retains its shape, and is often compared with the leaf of *asvattha* (*Ficus religiosa*). It is made of hard iron and has sharp edges. Thus the *desi* (indigenous) plow is a multipurpose implement, difficult to be replaced unless most efficient multipurpose improved implements are designed.

Sage Parashara was very particular about the care and humane treatment for draft animals. He said that farms should be cultivated in such a manner so that it does not inflict pain on draft animals. Grains obtained by the suffering of draft animals are condemned. Crops obtained through oppression of draft animals though grown four-fold are quickly destroyed by their sighs.

Other Agricultural Implements

Besides describing the plow and its accessories, Parashara also mentioned *viddhaka* (the harrow), which should have 21 spikes. It was probably used for opening furrows on leveled land to sow seeds or to collect crop residues before sowing. Another implement called *mudika* (or *madi*) was a plank for leveling the plowed land (Fig. 4). Other implements such as *abaddha* (disc harrow) and *phalika* (leaf shaped iron piece to replace the normal iron blade for deep plowing) are mentioned in Krishi-Parashara.

Several agricultural implements were used in ancient period (Figs. 5, 6, 7, and 8). Some examples are *srni* (sickle), *khanitram* (hoe), *musala* (pestle), *udukhala* (mortar), *surpa* (winnowing basket), *dhanyakrt* (winnowing fan), *calani* (sieve), and *medhi* (the central post of the threshing floor around which cattle turn to thresh out grains).

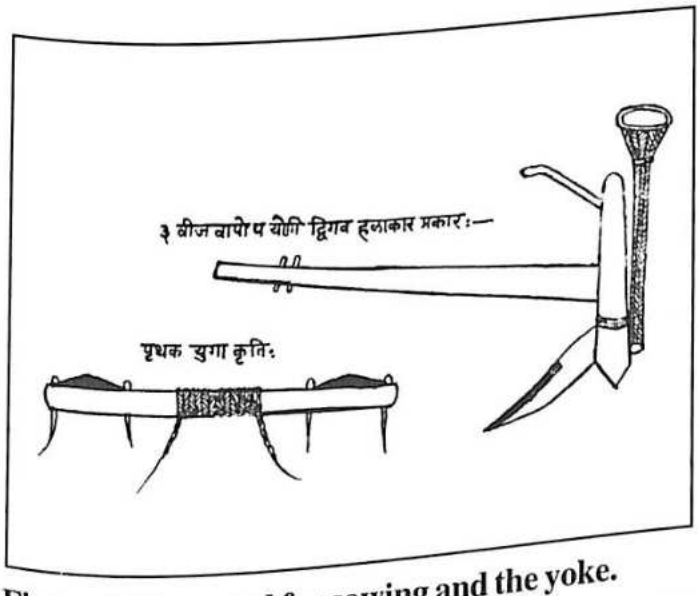


Figure 3. Plow used for sowing and the yoke.

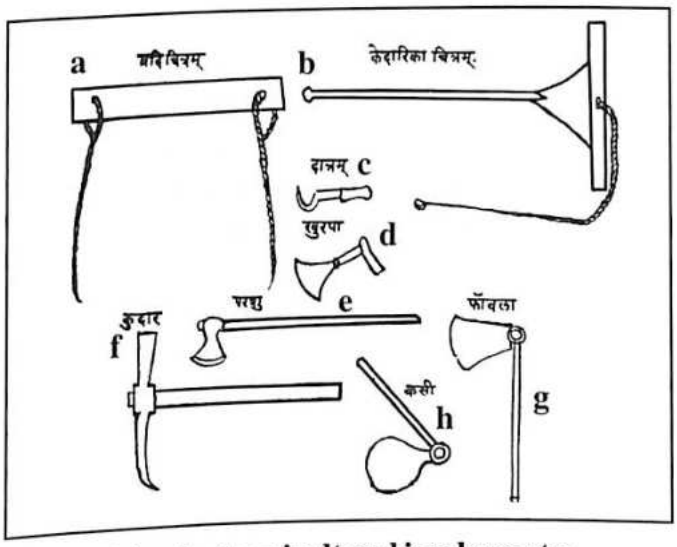


Figure 4. Ancient agricultural implements: (a) *Madi* (a plank for leveling plowed field); (b) *Kedarika* (a plank for leveling the field); (c) *Datram* (sickle); (d) *Khurpa* (tool for weeding); (e) *Parsu* (axe); (f) *Kudhal* (tool for digging earth); (g) *Phavla* (spade); (h) *Kasi* (spade).

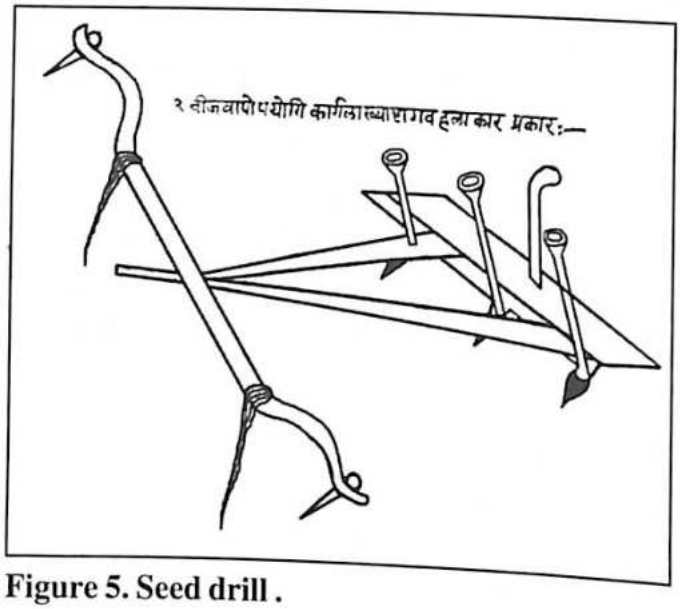


Figure 5. Seed drill .

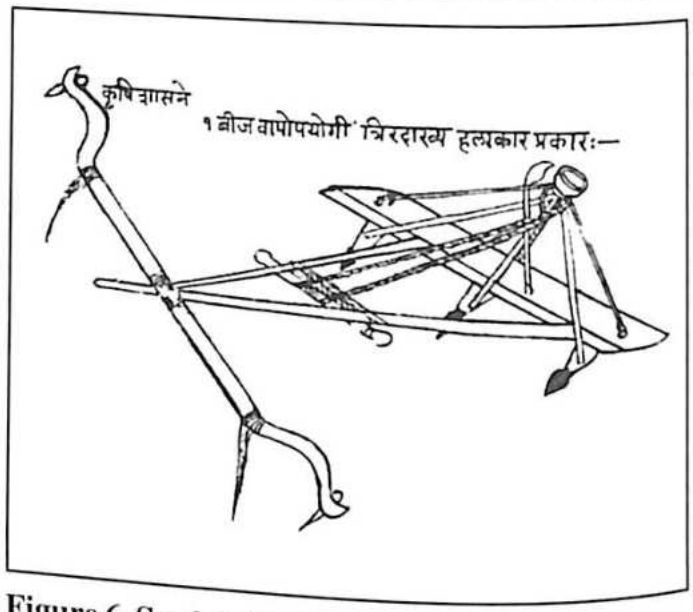


Figure 6. Seed drill still used in Maharashtra, India.

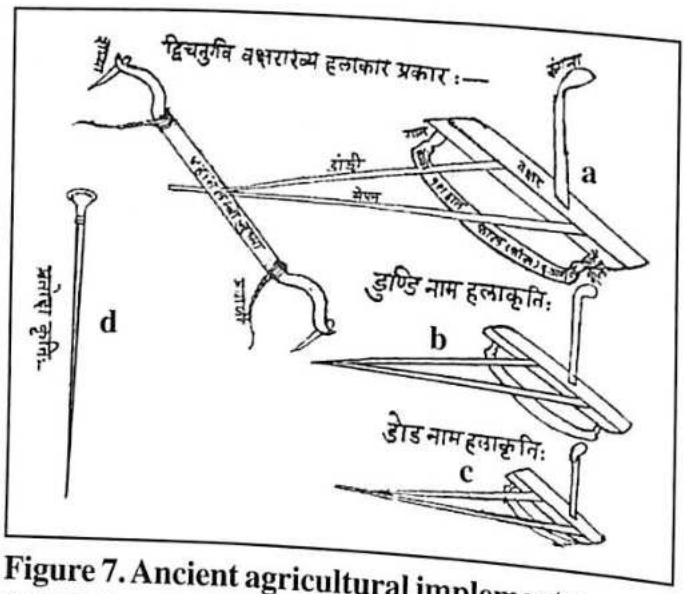


Figure 7. Ancient agricultural implements: (a) *Wakhar* (harrow); (b) *Dundi* (hoe); (c) *Dod* (small hoe used in close rows); (d) *Pratoda* (goad).

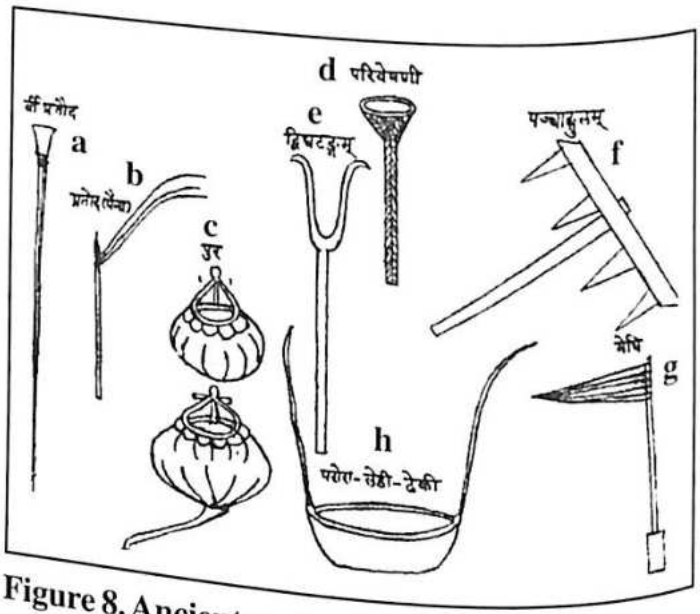


Figure 8. Ancient agricultural implements: (a) *Pratoda* (goad) used while driving harrow and also for cleaning the blade; (b) *Pratoda* (whip); (c) *Pur* (device to lift water from well); (d) *Pariveshani* (device for sowing seeds); (e) *Dwighatangam* (device for cleaning blade of harrow); (f) *Panchangulam* (device for making furrows for sowing); (g) *Medhi* (the central pole on the threshing floor); (h) *Parora-ledi-theki* (basket for lifting water from ponds).

Amarkosha provides the list of implements used at that time: *kautisam* (harrow), *prajanam* or *todanam* (goad), *khanitram* (spade or hoe), *datram* (sickle), etc. Parashara did not describe his *mudika (moi)* but simply states the length, which was about 14 feet. In many places the *moi* is a piece of rectangular timber and quite suitable for leveling soft loamy soils.

Both Panini and Patanjali mentioned agricultural operations with little difference in expression. When the crop was ready, reaping or cutting (*lavan*) with a sickle (*datram*) was the next step. The reaper was called *lavak*. After cutting the standing crop, the produce was brought to the threshing floor (*khala*) for threshing, which was followed by another process called *nispav*. A winnowing basket (*surpa*) was used by the winnower (*tandulik*), who might have been an agricultural laborer employed for the purpose of separating the grain from the chaff. Farmers kept threshing floors close by in mutual interest. After winnowing the grain from the chaff, it was stored in the granary called *kost* or *kushul*. The grain was stored for a specific period in jars called *kumbhidhanya*.

In ancient times the women took interest in farming. For example, Khana was the wife of Mihira, the famous ancient astronomer and son of Varaha, also an eminent astronomer and astrologer, who flourished in the court of Chandragupta II Vikramaditya (c. 600 AD). Khana herself was also an astrologer of repute and a large number of aphorisms, supposed to have been compiled by Khana, have been handed down to us. One of her maxims says, "Ridges made of earth should at first be constructed for the purpose of dividing the fields and for conserving water in the fields and then the seeds are to be sown." She also advised, "The farmer should conduct the cultivation operation in collaboration with his son, failing which, he should conduct it in collaboration with his own brother." This may be to keep the property undivided.

Agricultural Implements of the Deccan India

The Deccan (plateau region of South-Central India lying between Eastern Ghats and Western Ghats) possesses a series of agricultural implements. The ancient Tamil society in the Sangam Age, which stretched up to 3rd century AD, witnessed the development in agriculture. Agriculture was the main and esteemed profession of the Tamils. The poem Tholkappiyam written around 200 BC gives descriptions of various agricultural aspects and importance to agriculture. Another poem Tirukural gives us a vivid picture of agricultural practices during that period. *Pattuppattu* (ten idyls), *Ettutogai* (eight anthologies), and *Silappadikaram* also describe various aspects of agriculture.

The ancient Tamils were very systematic in cultivation. Oxen and plow were used for plowing. Buffaloes were also used to draw the plow. Tirukural gives a detailed account of agricultural activities. If the five steps, i.e., plow, fertilization, weed control, irrigation, and crop protection are followed in a proper manner the land would yield richly.

With the available raw materials, the ancient Tamils prepared various implements, which were necessary at each step of agricultural activity, i.e., from plowing to the end of harvest. The basic requirement was the plow which was known as *mezhi*, *nanchil*, and *kalappai*. It comprises a

wooden piece to tie the oxen and an iron plowshare to plow the land. The plow looked like the cut portion of an elephant's mouth and trunk. The plowing was to be in such a way that subsoil would be brought to the upper layer to make the soil airy and suitable for sowing. The wooden implement known as *palli* or *maram* was used for leveling the plowed land. For digging the soil, a wooden handle with sharp terminal (e.g., spade) was used. *Palliyadutal* refers to the removal of weeds by means of a toothed implement attached to a plank, which was drawn by oxen. A labor saving tool called *parambu* was used for leveling paddy fields.

The farmers used a bullock-drawn contrivance called *kapilai* for drawing water from deep wells and operated a contrivance called *erram* for shallow wells. Water pails were also known as *ampi* and *kilar*. Tools called *thattai* and *kavan* (stone slings) were used for scaring birds in millet fields; *tallai,* a rattling instrument was used to annoy some animals. Traps were used to catch wild boars in millet fields. A tool called *senyam* was used for harvesting rice. The land was immediately plowed after harvest or water was allowed to stagnate to facilitate rotting of stubbles. These agronomic practices are recommended even today based on scientific principles.

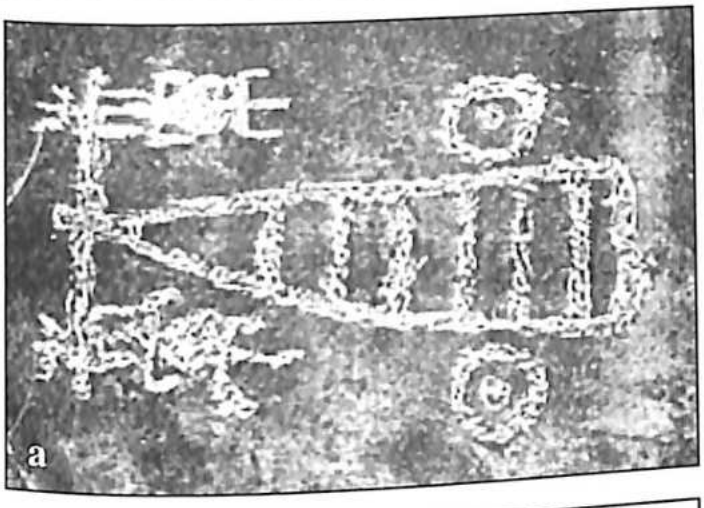
Sickles and swords were needed by the Tamils for reaping the ripe ears of corn. The grain was separated by thrashing the sheaths and ears of corn on the ground. The buffaloes were made to tread the sheaths to unloosen the remaining corn. Black gram (*Vigna mungo*) was separated by beating with a stick. Operations requiring hard work such as plowing were done by men, while women attended to light work such as transplanting, weeding, bird scaring, harvesting, and winnowing.

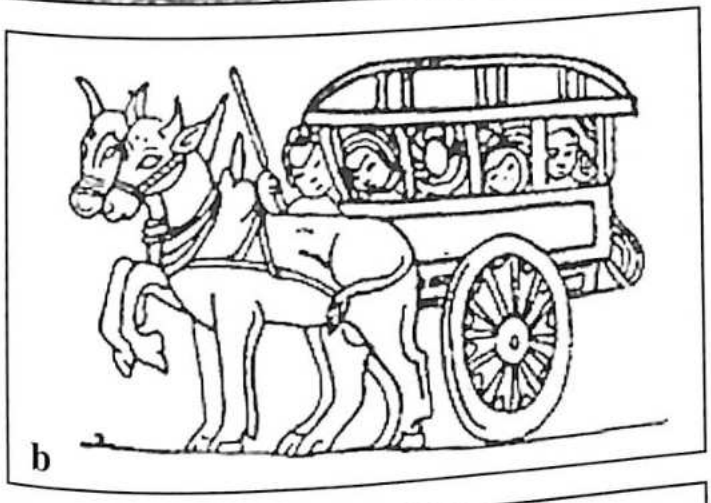
Ancient Bullock-cart

Bullock-carts are being used in India since the ancient times (Fig. 9). The inscription on stone found at Bhimbeteka in Madhya Pradesh (20,000 to 10,000 BC) by the late VS Wakankar depicts a bullock-cart used at that time. This bullock-cart has two wheels on an axle (*aas*) and each wheel has eight spokes (*ari*). A pair of bullocks is yoked and a man stands in front to drive the bullock-cart. In the Saraswati-Indus basin (2000 BC), bullock-carts with two and four wheels were used. In Harappa, the bullock-carts were used for common purpose and for hunting. In Sanskrit literature the bullock-cart is called *shakat* and *anas* and also *advah* in some places. For the construction of the *anas*, the wood of *khair* (*Acacia catechu*) and *shisham* (*Dalbergia sissoo*) was used.

In a marriage ceremony described in Rigveda, the bride was seated in the bullock-cart. Before starting the bullock-cart, ghee (clarified butter) was poured on the wheels and was worshiped with flowers and branches of a tree.

On the beam of the Jain stupa at Kankali Tilla (2nd or 3rd century AD) inscriptions of carts are seen. These carts are drawn by bullocks or horses and the wheels have spokes. The bullock-carts are open or covered. These bullock-carts were used for carrying persons, agricultural produce, or war material, or for hunting.





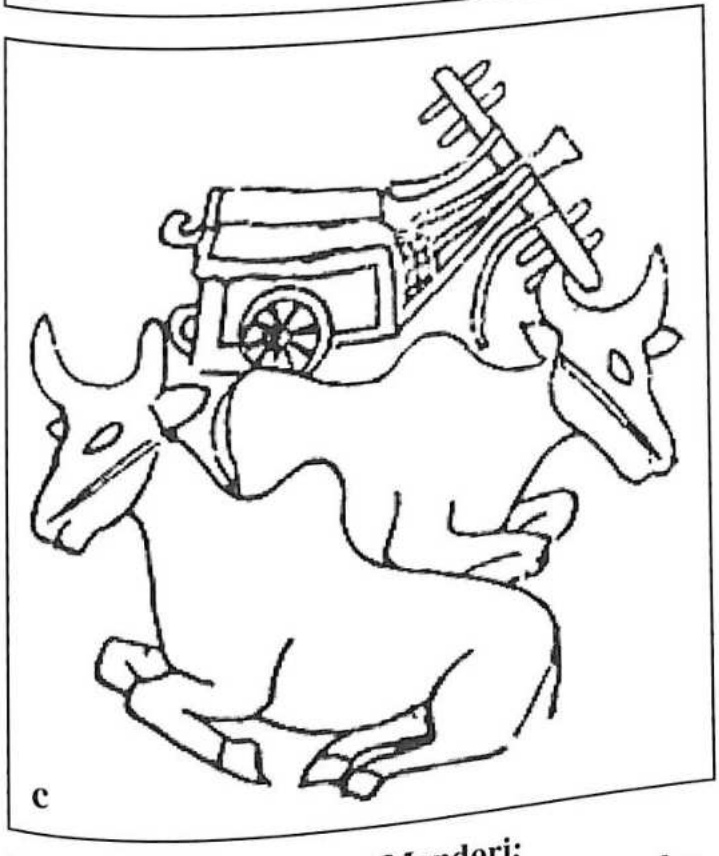


Figure 9. (a) Bullock-cart Mandori; (b) Bullock-cart carrying persons; (c) Bullocks resting near cart.

In the excavation at Inamgaon in Maharashtra, a toy bullock-cart made of bronze was found. At Brahmapuri in Kolhapur district of Maharashtra, two bullock-carts made of metal (2nd century AD) were found, of which one has two wheels with spokes, three beams, a cover, and a place for sitting for the driver; the other bullock-cart has only one beam. The salient features of these ancient implements were:

- Structure – Simple design; few components; easy to shape.
- Weight – Bearable and manageable.
- Materials used – Readily and easily available; convenient to handle by village artisans.
- Fabrication – Elaborate fabrication setup is not required; village artisans can fabricate with the skills used for other items.
- Easy to handle – Simple to operate; easy to adjust; not much training is needed; practice and experience required to develop proficiency.
- Easy to repair – Local material available; village artisans do the job; not much repair required because of simple structure and few components.
- Size – Matches with animal power (bullocks, buffaloes, donkeys, and camel).
- Performance – Satisfactory multiple applications.
- Cost – Practically inexpensive, within the reach of farmers because these are locally made; no transport cost; no mediators.
- Economics – Affordable, not costly.

Questions

1. Amarkosha denotes plowing after sowing as:
   (i) *Dwigunakritam* (ii) *Trihalyam* (iii) *Vijakritam* (iv) *Vijahalyam*
2. According to Krishi-Parashara, which of the following are parts of a plow?
   (i) *Yuga* (ii) *Niryola* (iii) *Addacalla* (iv) *Adhaka*
3. "Carry on cultivation in such a manner so that it does not inflict pain on draft animals." In which ancient text is the above statement made?
   (i) Brihatsamhita (ii) Vishvavallabha (iii) Nuskha Dar Fanni-Falahat (iv) Krishi-Parashara
4. *Abaddha* is the Sanskrit word for:
   (i) Plank (ii) Disc harrow (iii) Seed drill (iv) Special plow
5. How was Khana, the famous astrologer, related to Varahamihira?
   (i) Daughter (ii) Mother (iii) Niece (iv) Daughter-in-law

CHAPTER 12

WATER MANAGEMENT

Water is an essential commodity for life. Hence the ancient civilizations of the world developed and thrived on the banks of rivers such as Indian civilization on the banks of Saraswati and Sindhu, Egyptian civilization on the banks of Nile, Chinese civilization on the banks of Huanghe and Yangtze, and Mesopotamian civilization on the banks of Euphrates and Tigris rivers. Our ancestors very well understood the importance of water to living beings. In Rigveda, earth and sky are referred to as the mother and father providing food and water to all living beings.

Water Resources

Successful farming requires careful planning for all farming activities including water resources. The people of ancient time knew that rain was the only source of replenishing water in rivers to provide clean and safe drinking water for them and their domestic animals. They also knew that water was essential for growing food grains from soil and green pastures for their cattle – their precious wealth. They had a very clear idea about the water cycle and that water on earth evaporates resulting in cloud formation and then comes down again in the form of rain. They also knew that rains lasted for four months of the year starting after the Sun starts moving southwards (i.e., 22 June). In Atharvaveda five sources of water are mentioned. These are: desert (occasional showers), ponds, wells, pots, and seasonal rains which were the only dependable source for a large area under cultivation.

As rain is the only source of water availability, knowledge of rainfall is, therefore, a primary need for agriculture. This knowledge consists of having advance information about rainfall. Parashara described some meteorological concepts for the prediction of rainfall based on "ruler planet", "minister planet", and the clouds. He described four different types of clouds – (i) *Aavarta,* (ii) *Samvarta*, (iii) *Pushkara*, and (iv) *Drona*. Once the type of the cloud for the *Saka* year has been identified, then the amount of rainfall that this particular type of cloud would shed during the *Saka* year can be estimated. The process of measurement of rainfall in a particular area has also been given by Parashara. For this he gave a term "*adhaka*" or "*meghjala*" as a measure of water which is the quantity of rain water contained in a land expanse of 100 *yojanas* in length and 30 *yojanas* in width, where 1 *yojana* was equal to 4 *kroshas* or 8 miles or 12.8 km (approximately 13 km).

Area 100 *yojanas* × 30 *yojanas*

i.e., 100 × 13 = 1300 km length and 30 × 13 = 390 km width

i.e., 1300 km × 390 km = 507,000 km^2

Hence the quantity of water wetting an area of 507,000 km^2 was called *adhaka*.

Kautilya (321–296 BC) refined the technique of measurement of rainfall. In this technique a circular vessel, having a diameter equal to the distance measured by eight fingers was used to measure rainfall. When the vessel was filled with the rain water collected in open space, the rainfall was 50 *palas* or one *adhaka*. Four *adhakas* were equal to one *drona* of rainfall. Kautilya's method for fixing the unit is stated to be more scientific, precise, and free from other imperfections. In modern unit one *drona* is equal to 6.4 cm.

Harvesting and Storing of Water

Due to variation in the quantum of rainfall, it was required to store rain water for subsequent use. When the rain water filled the low-lying area of land, a lake was formed automatically. Inspired by such a natural phenomenon ancient people started storing water by making small tanks, ponds, and wells.

Collecting and storing surplus water during rainy season and using it during lean season seems to be an important strategy that our farmers have used through ages. The practice of storing water is called "water harvesting". Although the term "water harvesting" is of recent origin, the practice is at least 4,000 years old in India, where small tanks and diversion works were used for irrigating the crops.

In Rigveda both *kaccha* (temporary) and *pucca* (permanent) wells are mentioned which probably seem to be the most ancient form of man-made storage structures. These wells were used both for drinking purpose and irrigation. Existence of dams over rivers is mentioned in Rigveda but they were not constructed by man. Therefore, it seems that when a boulder comes in the flow of water, such types of structures may be seen. Dams were considered harmful to human interest by the ancient people; hence, the people prayed to Indra (the God of rain) to remove such barriers for perpetual flow of water.

During the Mauryan era dams were constructed by the state at strategic points with sluice gates to harness river water with proper regulation facilities (*setus*). Two types of dams are described by Kautilya:

1. *Sahodaka setus* – constructed for tanks and wells fed with natural springs of water.
2. *Aharyodaka setus* – constructed for reservoirs where water needs to be stored externally.

Cooperative efforts for the construction of big water reservoirs were encouraged particularly in new settlement where it was compulsory for the people of that settlement to contribute their share of labor and expenses. There was exemption in the tax for five years for those who constructed new tanks privately for irrigation. Prior to Kautilya's perception, water management was taken care of by individuals at a very small scale. The state's involvement combined with cooperative approach changed the entire perspective of water management. Kautilya's views on water management are therefore closer to the present-day perceptions of the subject. During the period of Ashoka (304–232 BC) several wells were built for drinking and irrigation purposes.

During 700–800 AD much emphasis was given to explore alternative methods of irrigation which included the construction of water reservoirs. Kashyapa, in his treatise "Kashyapiyakrishisukti", gave the following details for the construction of water reservoirs:

- The water reservoirs should be constructed deep and in longish, round, circular, or semicircular shape.
- The level of ground and direction should be considered.
- Strong and safe steps should be considered for approaching water.
- These should be equipped with inlets of water and thus be close to a bigger lake situated at higher level or to a mountain spring.
- While constructing water reservoir on ground level, it must be ensured that the ground is firm; the reservoir should be big enough to hold abundant water.
- Safety measures like providing latches should be taken to ward off floods.
- These should be regularly examined in rainy season.
- *Nimba* or neem (*Azadirachta indica*), *kadamba* (*Anthocephalus cadamba*), and such other trees should be planted in the vicinity to ensure the purity of water.

Apart from the construction of big water reservoirs, Kashyapa also gave instructions regarding digging wells.

In order to explore presence of groundwater, several indicators like flora, fauna, and soil texture and color were considered. The plants as indicators of groundwater are described by Surapala (c. 1000 AD). Some of these are:

- *Jambu* or black plum (*Syzygium cuminii*)
- *Badari* (*Ziziyphus mauritiana*)
- *Palasha* (*Butea monosperma*)
- *Kasha* (*Saccharum spontaneum*)
- *Munja* (*Erianthus munja*)
- *Bibhitaka* (*Terminalia bellirica*)

The fauna considered for this purpose were frog, ant (anthill), fish, earthworms, white mouse shrew, whitish scorpion, and pinkish snake.

After taking into account these factors, the depth, direction, taste, the force of underlying water currents, and the length of time they would last were inferred. Based on these data the spot for digging well was selected. Some of the examples are given below:

- On digging the depth of half man-height, if a frog of whitish color and yellow soil are seen then these are indications that on penetrating further through the layers, the rock beneath will contain abundant water.

- A land which is full of *munja* or *kasha* and where the soil is grainy and of bluish color, there the water is in ample quantity and of sweet taste. Also if the soil is black or red, water is sweet and abundant.
- If close to the *jambu* tree, there is an anthill, then to the southern side of the tree there is plenty of water at the depth of two man-height.
- A reddish grainy soil makes the water astringent in taste, the land of tawny (orange-brown or yellowish brown) color makes it caustic; the whitish land is stated to make the water saltish while the blue land makes it sweet.
- If an anthill is seen to the south in the vicinity of *bibhitaka* tree, then to the east thereof water current flows at one and a half man-height. And if the anthill is to its west at a distance of one hand, water current flows at the depth of four and a half man-height.

Construction of reservoirs for harvesting and storing water was the vital need of the arid and semi-arid regions. For this a number of different structures were made and some are described below.

Tanka

Harvesting of rain water in *Tanka* has been one of the ancient and relatively hygienic methods of water storage and has been the main source of drinking water in desert. *Tanka* was constructed on the farm, in houses or palatial buildings, etc. In forts and houses it was constructed mainly for harvesting roof water. A 2-m diameter and 3-m deep *Tanka* has capacity to store 10,000 liters of water and was common on farms. The *Tanka* was made on sloping land to arrest runoff water in the farm. In the Thar Desert of Rajasthan both *kaccha* and *pucca Tankas* are still found depending on the financial condition of the farmers. The rulers of Jodhpur created unique rain water harvesting system in the territories and forts. In Meharangarh fort *Janana Deodi Tanka* is existing as a living example. This *Tanka* is an underground water reservoir for storing rainwater harvested from the catchment area. Later rulers added collection of rain water from the roof and adjoining area of the place. For the past 450 years this reservoir has been fulfilling the drinking water requirement of the royal family.

Talai

Similar to *Tanka*, *Talai* was also one of the oldest methods of harvesting rain water. *Talais* were mostly constructed in towns. A *Talai* was about 2 to 3 m deep. In contrast to tanks, the *Talai* was kept open. To make use of stored water, a staircase was provided in the *Talai*. In Bikaner *Tat Talai* in Deshnok still exists and is being preserved as one of the monuments. It is square in shape having about 60 m length and 60 m width with 2 m depth. It has capacity of storing about 8 million liters of water.

Nada

Nada was a common reservoir for storing rain water in the villages of the Thar desert. *Nada* was constructed on range land, barren land, or pasture land in low-lying area between hillocks.

An embankment was made to arrest rain water from these hillocks. The catchment area of the *Nada* ranged from 5 to 10 ha. *Nada* served as a short-term storage structure of rain water mainly for animals.

Khadin

Khadin is an ancient indigenous rain water harvesting method mainly found in arid regions. The accumulation of runoff water between hillocks is called *Khadin*. The *Khadin* water was generally used for cultivation under preserved moisture conditions and for animal consumption. When this stored water dried up, the farmers used the land for farming or left it undisturbed for generation of grass for use as fodder for animals. In *Khadins*, rain water accumulates in large areas of 1.5 km^2 or more.

In addition to the reservoirs mentioned above, several other structures for harvesting rain water are also found in Rajasthan. These are *Talab*, *Nadi*, *Sar*, *Sagar*, and *Samand*. Similar reservoirs were constructed in the other parts of the country like *Baudis* and *Tals* in Maharashtra; *Baudis* and *Havelis* in Madhya Pradesh and Uttar Pradesh; *Ahars* and *Pynes* in Bihar; *Kuhls* and *Kuls* in Himachal Pradesh and Jammu and Kashmir; and *Zing* in Ladakh.

Due to the use of groundwater and availability of canal water due attention is not being given for the maintenance of these ancient water reservoirs.

Chakrapani Mishra was a scholar attached to the court of Maharana Pratap (1540–1597 AD) of Mewar (Udaipur). Chakrapani wrote "Vishvavallabha", which deals with:

- Detection of groundwater in arid and semi-arid regions, and hills
- Construction of water reservoirs
- Types of soils
- Crops to be grown

Vishvavallabha closely resembles Surapala's Vrikshayurveda and deals with the same subjects.

Irrigation

When the primitive man learned the process of growing crops for his own necessity, the only source of getting water for his crops was rain. But when there were no rains, he drew off water from rivers and natural lakes and in this way irrigation was invented.

In Rigveda, irrigation from wells has been mentioned. For this water was raised from wells by means of a strap and water pails and also by buckets tied with a rope to one end of a long wooden pole working on the fulcrum. The other end of the wooden pole carried a heavy weight. The water was lifted in the bucket by the gravitational force acting on the heavy weight. Such system of irrigation can be seen even today in the rural areas. The ancient people had efficient craftsman called *Ribhus* who used to dig channels from rivers to the field to carry water for irrigation.

Around 3000 BC, the farmers of Baluchistan impounded rain water by using stone rubble dams for irrigation. Similar structures have been found in Kutch, Sabarkantha, and Bhavanagar in Gujarat and also near Karachi in Pakistan. Evidence of the collection of monsoon runoff is available in Dholavira, a major site of the Indus Valley civilization.

During 4th century BC, the irrigation canals were constructed by the kings of Nanda dynasty. In the period of Chandragupta Maurya also, emphasis was given to irrigation system by constructing dams and lakes. The canals were dug and water stored in reservoirs was carried to the fields for irrigation. Sudarshan Lake in Girnar of Gujarat is one such example. It is datable to the early period of the reign of the Mauryan dynasty emperors. This was first excavated during the reign of Chandragupta Maurya by one of his subordinates, an officer named Pushyagupta. Supplementary channels were later added, along with other improvements to the lake, by one 'Yavanaraja' Tushaspha during the reign of Emperor Ashoka (Chandragupta Maurya's grandson), in the 3rd century BC. Nearly four centuries later, the lake was repaired by the Saka king, Mahakshatrapa Rudradaman of Ujjain, as is recorded in his Junagarh (or Girnar) Inscription of 150 AD. The lake continued to exist over the ensuing period, as is attested by an Inscription of 455 AD by the local city governor, a man named Chakrapalita, son of Emperor Skandagupta's Provincial Governor, Parnadatta. Much later, the great embankment, over 100 feet thick at its base, holding back the waters of the lake at Girnar finally gave way sometime in the 9th century AD. It was never repaired again.

Irrigation was one of the sources of state income. Depending on the lifting of water from state-owned irrigation works by bullocks or other mechanical method like Persian wheel, etc., farmers were required to pay taxes from the farm produce.

In 2nd century BC, Hathigumta inscriptions showed the description of the major tanks in Kalinga (modern Orissa). In Tamil Nadu, one Chola king constructed a stone dam across the river Cauvery in 200 BC. This dam is considered as master piece of engineering even today. The river water was directed to tanks for irrigation through channels.

During the medieval period also, much emphasis was given to the development of water reservoirs and irrigation. Artificial irrigation supporting agriculture has been found in Inamgaon site in Maharashtra which is a large mud embankment with stone foundation. The reservoir was connected with the Ghod River. It is presumed that flood water of the river was stored for irrigation purpose. A water reservoir was constructed in Bhopal, Madhya Pradesh by King Bhoja in the 11th century. Pandyan and Chola kings (750–1300 AD) constructed a number of tanks for irrigation in Tamil Nadu and by the 13th century there were more than 30 *nadus* (regions) depending on tank irrigation.

Between 1351 and 1378 AD, Feroz Shah Tughlaq executed many public works particularly dams across the rivers and canals to carry water from dams to farmers' fields. During this period five canals were dug; among these the most important was the Western Jamuna Canal. Mughals repaired and restored the canal. In this system of irrigation salty patches

were developed in the soil which disappeared when the canal went into disuse after the fall of Mughal Empire.

During East India Company's rule, the Ganges canal was constructed to irrigate large areas of Uttar Pradesh. The Gang canal was built (1922–1927) with the initiative of Maharaja Gang Singh (1880–1943) of Bikaner to irrigate the area in the princely state of Bikaner. Similarly the Sharda Canal Project was completed in 1926 for irrigation in the United Provinces of Agra and Awadh. After independence (1947), several irrigation-power projects were undertaken; the important ones are given below:

- The Kakarpara barrage on the river Tapti in Gujarat (1949–1955)
- The Matatila dam on the river Betwa near Jhansi in Uttar Pradesh (1952–1958)
- The Panchet hill dam on river Damodar near Dhanbad, Bihar (1952–1959)
- The Hirakund dam on the river Mahanadi, Orissa (1948–1957)
- The Durgapur barrage on Damodar river, Bihar (1952–1959)
- The Bhakhra dam on Sutlej river in Bilaspur, Himachal Pradesh
- The Chambal Project which includes Gandhi Sagar Dam (1954–1960) and Rana Pratap Sagar (1961–1967) on the Chambal river.
- The Nagarjunasagar Project on the Krishna river in Andhra Pradesh which is one of the biggest projects in India.

The Rajasthan Canal Project now known as "Indira Gandhi Nahar Pariyojana", one of the largest canal systems of the world, is a gigantic human effort to transform a part of the vast Thar desert into a land of prosperity.

Thus we see that during the colonial rule and post-independence era, major and multipurpose projects were undertaken and huge water reservoirs were constructed. Today we know that every big irrigation project launched during this period in India was followed by soil salinization and waterlogging. It is interesting to note that none of the indigenous water-harvesting structures is known to ever impair soil quality. Therefore, efforts should be made to revive the age-old tank irrigation system by adopting the following strategies:

- Desalting of tanks and the repair of the existing tanks
- Avoiding tank-bed irrigation
- Lining of irrigation channels
- Regular maintenance and repair
- Control of water distribution
- Construction of new tanks
- Remodeling of anicuts across the river to increase the supply of water to tanks

Questions

1. The Indian civilization developed on the banks of:

   (i) Saraswati-Sindhu (ii) Ganga (iii) Yamuna (iv) Sutlej

2. Parashara described four types of clouds from which rainfall was predicted. Which of the following are mentioned by Parashara?

   (i) *Pushkara* (ii) *Drona* (iii) *Adhaka* (iv) *Mriga*

3. The term "water-harvesting" is a modern one. However, how many years ago have our ancestors been following water-harvesting?

   (i) 10,000 (ii) 6,000 (iii) 4,000 (iv) 1,000

4. Plants as indicators of the presence of underground water were mentioned by Surapala. Which of the following did he mention?

   (i) *Jambu* (ii) *Palasha* (iii) *Arjuna* (iv) *Bibhitaka*

5. The ancient Sudarshan Lake was located in:

   (i) Dwaraka (ii) Mathura (iii) Girnar (iv) Indraprastha

CHAPTER 13

HISTORY OF FRUIT CROPS

The ancient Indian civilization was mainly dependent upon and intimately related to forest and flora. In India fragments of ethno-botanical lore may possibly be gathered from the time of Rigveda (c. 8000 BC).

Vedic works provide literary evidence that shows a methodical investigation of Indian plants by the Aryans around 1800 BC. In Manusmriti (c. 200 BC) and later in the Puranas, the man-plant relationship became deeply intimate.

The Puranas (200 BC to 750 AD) contain detailed ethno-botanical information. In Brihatsamhita (c. 6th century AD) there are references to the methods of propagation like cuttings, grafting, and other methods of propagation. Propagation of jack fruit, Java plum (*jamun*), and grapes has been mentioned and methods of root grafting and stem grafting were recorded. In fact, Sadhale (1996) draws a resemblance between Vrikshayurveda of Surapala (c. 1000 AD), Upavanavinoda[1] of Sarangadhara, and Brihatsamhita of Varahamihira in respect of plant life. The Brahma Vaivarta Purana (c. 750 AD) lists some fine fruits which include indigenous ones like mango (*amra*), banana (*kadali*), jack fruit (*panasa*), and Bengal quince (bael) which are considered as ancient and sacred fruits extensively used in *pujas*, religious festivals, and ceremonial occasions.

Vishvavallabha of Chakrapani Mishra (c. 1577 AD), another classic similar to Vrikshayurveda, contains some very interesting information like "wonder of fruits", viz., seedless fruits, size of fruits, etc.

Diversity

India has been enriched considerably by a continuous influx of new crop species and their specific cultivars. The Mughals, Spaniards, Portuguese, and the British introduced new fruit crops like apple, pear, peach, apricot, grape, almond, date palm, cashew, litchi, strawberry, blueberry, and pineapple.

The current matrix of diversity available in India consists of genepools of indigenous crops and introduced agro-horticultural and plantation crops. The Indian subcontinent is a center of domestication and diversity of wide array of plant material and is designated as Tropical South Asian Centre or the Hindustan Centre, an important center of diversity of crop plants.

1. A Sanskrit text "Sarangadhara Paddhati", an anthology compiled by Sarangadhara, who was a courtier of King Hammira of Bundelkhand contains a chapter "Upavanavinoda" dealing with arbori-horticulture.

Major Important Fruits

Mango

Mango (*Mangifera indica*), a pre-eminent tropical fruit, has been described as the "choicest fruit of Hindustan" by Mughals. Historical records indicate that mangoes have been cultivated in India since 4000 to 5000 years ago. It has been closely associated with Indian way of life since time immemorial and has a universal appeal to all sections of the society. Hindus consider mango tree as the symbol of "Prajapati", Lord of Creation. Mango tree is believed to be useful in scaring away evil spirits. The nutritive value of mango has been mentioned in Kurma Purana. The oldest Indian literature dating back to Vedic Upanishad periods, Brahadaranyaka Upanishad (c. 1500 to 1000 BC) and a little later Shatapatha Brahmana mention the mango tree. Greek historians have recorded the occurrence of mango and tamarind, probably after the report of Alexander who invaded Northwest India around 330 BC. Lord Buddha (563–486 BC) was accustomed to resting under the shade of mango tree. In Jataka literature of Buddhists, reference to mango has been noted. Likewise in Jain literature written after Lord Mahavira (527 BC), mango trees were called "Sahasramarvana". Kautilya's Artha-sastra (321–296 BC) and Charaka Samhita (c. 700 BC) mentioned mango tree and ripening of mango fruit. In the first millennium AD, in Kalidasa's (370–450 AD) "Meghdootam" (a Sanskrit classic), mango trees have been recorded. Chinese travelers Yuan Chung (645 AD) recorded the growing of mango trees in household gardens around Mathura, south of Delhi. Indians might have known 'wedge' grafting as early as in 6th century as a method of propagation of mango. In medieval period (600–900 AD), kings in Orissa had right over all mango trees. In Vrikshayurveda of Surapala (c. 1000 AD), Vishvavallabha of Chakrapani Mishra (1577 AD), and Nuskha Dar Fanni-Fahalat of Dara Shikoh (1650 AD) details of mango trees have been given. Chakradhar Swamy (1194–1274 AD) and his desciples planted mango trees in thousands near Phulambri (Aurangabad, Maharashtra).

Receiving mango fruit as a gift from India on a particular day was considered by Babur (the founder of Mughal Empire) to be a good omen to invade India. Akbar, Babur's grandson, established "Lakhi Bagh" near Darbhanga in Bihar and a description of mango is given in "Ain-i-Akbari". Akbar's son Jahangir, a naturalist, was an admirer of mango fruits. Mango orcharding became a prerogative of Nawabs during the Mughal period especially in Uttar Pradesh and Bengal. Grafting for getting high quality mango was permitted only in royal gardens.

Europeans especially Portuguese, French, and British traders and travelers took a fancy for mango fruits. Early foreign travelers, Yuan-Chang (629–645 AD), Ibn Batouta (1304–1368 AD) and Ludo bici Verthena (1503–1508 AD), all praised the mango fruits in their travelogues. Grafting method of vegetative propagation became a common practice by them. Mango varieties Alphanso (Aphoos), Pairi, Safeda, Fuzlee, Langra, Mulgoa, Banganpalli, etc. have become popular.

There is no doubt that mango originated in northeastern India and the adjoining region of Myanmar. Of the 39 valid species of *Mangifera, M. andamanica, M. indica, M. khasiana*, and *M. sylvatica* are found naturally occurring in India. Another species *M. camptosperma* is also

found in Andamans. *Mangifera indica* is seen in wild form with very small fruits in Indo-Myanmar border and in Chittagong hill tracts of Bangladesh. *Mangifera khasiana* is found in hills of Assam and *M. sylvatica* is mainly distributed in Assam, Tripura, Manipur, and West Bengal and is known as "Haibamin" in Tripura.

There is a rich heritage of mango varieties in India, mainly because of interest and fancy by Mughal rulers, Nawabs, Maharajas and landed aristrocacy. There are several interesting mango varieties like regular bearing scented varieties "Haldibas", "Pausha" of Orissa, dwarf and late maturing, "Moreh" from Manipur bearing sweet fruits and high pulp ratio, and a pickling variety in western Uttar Pradesh bearing 25–30 fruits in a cluster. India has been the world leader in mango production and the Indian mango wealth has to be conserved and protected for posterity.

Banana

The banana (*Musa* sp.) is as old as civilization itself and is among the oldest fruits cultivated by man. On the basis of philological studies, we can say that in pre-historic times people took *kadali* (Sanskrit name of banana) as food. The hoary past of bananas can be traced in Indian scriptures. It is noteworthy that the plantain (syn. banana) deity, identified with the goddesses Lakshmi and Parvati, is an agricultural deity called "Navapatrika". Kautilya's Artha-sastra (321–296 BC) mentions the roots of plantain (*kadali*) prevent grains from boiling or cooking soft. The famous Tamil classic Silappadikaram (500–600 AD) mentions the use of plantain leaves as dining plates. The banana was found in cultivation in the Indus valley as early as 336–323 BC by the army of Alexander. It seems that Arab traders have taken banana from India to East Africa.

The original home of banana is traced to be in Indo-Malaysian region linking northeastern states of India with Myanmar and Malaysia. Malaysia has been designated as primary and Northeast India as secondary center of origin of *Musa*.

Citrus

Citrus (*Citrus* spp.) is considered to be native of China and Southeast Asia. There is, however, a wealth of indigenous germplasm in citrus in India. Even though it is doubtful whether citrus is found in truly wild condition, there are several forms growing semi-wild in the country. The species which are undoubtedly indigenous to India include *Citrus indica, C. latipes, C. megaloxycarpa, C. karna, C. jambhiri, C. aurantifolia* and possibly *C. aurantium, C. medica, C. madurensis*, and *C. limon*.

Bael

The bael fruit (*Aegle marmelos*) (*bilva* tree) has been known in India from pre-historic times. The leaves are traditionally used as sacred offering to Lord Shiva. In Ramayana the bael tree has been mentioned as growing in Chitrakuta hills and Panchavati. Bael fruits were mentioned in the Vedic times and also in early Buddhist and Jain literature (c. 600–325 BC). Bael fruit is also mentioned in Upavanavinoda and Brihatsamhita. The medicinal properties of the fruit have been dealt in Charaka Samhita. The nutritive value has been recorded in Kurma Purana mentioning it as *sriphala*.

Jack fruit

Jack fruit (*Artocarpus heterophyllus*) is believed to be a native of India. It is an ancient fruit mentioned in Brihatsamhita and in Ramayana occurring in sage Bhardwaja's hermitage in Chitrakuta hills and in Agastya's hermitage in Panchavati. Its nutritive properties have been recordrd in Vayu and Kurma Puranas. Tamil classic Silappadikaram also mentions jack fruit as a sacred tree.

Aonla

Aonla or *amla* (*Emblica officinalis*) is a native of India, particularly of South India and is commercially cultivated in Uttar Pradesh. This fruit is extensively used in Ayurvedic medicines because of high vitamin C content. Its nutritive value has been referred in Vamana Purana.

Phalsa

Phalsa (*Grewia subinaequalis*; syn. *G. asiatica*) is indigenous to India and is recorded in Brihatsamhita and Charaka Samhita. It is suitable for commercial planting near cities for quick disposal of fruits.

Jamun

Jamun (*Syzygium cuminii*) is native to India and Southeast Asia. It is mentioned as *jambu* in Ramayana, Brihatsamhita, and in Kalidasa's Sanskrit plays. Its nutritive value has been reported in Vayu and Kurma Puranas.

Ber

Ber (*Ziziphus mauritiana*) is believed to have originated in Indo-Chinese region. It is pictured in Mohenja-daro seals. In Ramayana it is recorded as occurring in Chitrakuta hills.

Grape

Grape (*Vitis vinifera*) is considered as an ancient plant even older than wheat and rice. Egyptian references on viticulture and wine making date back to 5000–6000 years. The exact chronology of introduction of grape from Central Asia to India is not known. Vedic Aryans mentioned this in Vedas. Agni Purana describes its use as alcoholic drinks. The acclimatization and adaptation of a subtropical fruit plant to tropical conditions of southern Maharashtra, Andhra Pradesh, and Tamil Nadu is a significant contribution of Indian farmers, who have transformed the grape cultivation into a highly profitable venture with adequate technology inputs. *Vitis lanata* and *V. parviflora* are recorded wild species in India.

Date

Wild date (*Phoenix* sp.) is mentioned in Ramayana as growing in Panchavati and it is also seen in potsherds of Mohenjo-daro.

Pomegranate

Pomegranate (*Punica granatum*) is a fruit of antiquity known to have been cultivated in Middle East for more than 5000 years. It must have been introduced very early into India from Iran and Southern Russia. It is mentioned in several Puranas as *dadima*.

Fig

Brihadaranyaka has recorded the fig tree (*Ficus* sp.), indicating its antiquity. The tree has also been mentioned in Ramayana and Mahabharata.

Others

Further, there are several less known indigenous fruits like *latka* (*Baccaurea sapida*), palmyra (*Borassus flabellifer*), *chironji* (*Buchanania lanzan*), *ker* (*Capparis decidua*), *karonda* (*Carissa carandas*), jaggery palm or toddy palm (*Caryota urens*), *chalta* (*Dillenia indica*), *tendu* (*Diospyros melanoxylon*), rose apple (*Syzygium jambos*), cluster fig or *gular* (*Ficus glomerata*), *kantai* (*Flacourtia indica*), *kokam* (*Garcinia indica*), custard apple (*Annona squamosa*), wood apple (*Limonia acidissima*), mahua (*Madhuca indica*), *khejri* (*Prosopis cineraria*), and Indian almond (*Terminalia catappa*) having potential for cultivation, considering the diverse agroclimatic conditions of India.

Questions

1. Propagation by grafting was mentioned first in:
   (i) Vedas (ii) Puranas (iii) Brihatsamhita (iv) Kautilya's Artha-sastra
2. Which of the following fruit crops were introduced into India by foreigners?
   (i) Mango (ii) Cashew (iii) Pineapple (iv) *Jambu*
3. Who planted mango "Lakhi Bagh" near Darbhanga in Bihar?
   (i) Ashoka (ii) Chandragupta (iii) Akbar (iv) Babur
4. The primary center of origin of banana is most likely:
   (i) Malaysia (ii) Myanmar (iii) Northeast India (iv) South India
5. Amongst the following, which fruits are indigenous to India?
   (i) *Karaunda* (ii) *Tendu* (iii) Loquat (iv) *Khubani*

CHAPTER 14

HISTORY OF ORNAMENTAL PLANTS

Man is inseparable from nature. Since pre-historic times, the Indians have had close relationship with nature, particularly plants and flowers. The cult of tree worship has been a tradition and faith in India through the ages. Tree and flowers have been sanctified in Indian mythology, history, art, and socio-religious culture. The pre-historic and post-historic man in the Indus Valley had great reverence for trees and worshiped them during the Chalcolithic period. Tree was worshiped in its natural form and as tree spirit personified as human attributes in Mohehjo-daro and Harappa. The divine character of the tree has been depicted in several seals, sealings, potteries, potsherds, and some rock paintings as archaeological evidences of the Mohenjo-daro and Harappa period (2500–1750 BC). A few trees, such as *asvattha* (*Ficus religosa*; pipal), neem (*Azadirachta indica*), *katha* or *khadira* (*Acacia catechu*), and *jhand* or *sami* or *khejri* (*Prosopis cineraria*) were held sacred by the ancient people of the Indus Valley. It was believed that trees were symbolic of gods and goddesses, which dwelt in them (*vriksha devata* or *vriksha devi*). In ancient India trees were considered to be divine and spiritual.

There has been vast secular literature and texts, both Vedic and post-Vedic, like Vedas, Aranyakas, Upanishads, Sutras, Smritis, Mahakavyas, Puranas, Buddhist texts (Jatakas), and Jain literature (Sutras). The sages of the Upanishads have described the Cosmic Tree rooted in the Brahman, the ultimate, whose branches are space, wind, fire, water, and earth. The Cosmic Tree is the World Mother, the Goddess of nature, which nourishes all life. *Kalpavriksha* (wish-fulfilling tree) and *Kalpalata* (wish-fulfilling creeper) are mythological tree and creeper, not mentioned in the Vedic literature, which have been a part of folk cult in Hindu mythology. *Kalpavriksha* is mentioned in Ramayana, Mahabharata, Jatakas, Divyavanadana, and the Jain Sutras. In Brahamanical religion, *vata* (*Ficus benghalensis*; banyan) was identified with Shiva, *asvattha* (*Ficus religiosa*) with Vishnnu, lotus with Surya (Sun), and nine leaves of nine trees (*navapatrika*) with nine different aspects of Durga.

There are vivid descriptions of trees in the Rigveda (c. 8000 BC), the Ramayana (c. 5000 BC), the Mahabharata (c. 3000 BC) as well as other literature by Shudraka (100 BC), Kalidasa (370–450 AD), Ashvaghosha (100 AD), Vatsyayana (300–400 AD), and Sarangadhara (1283–1301 AD). The art of gardening and kinds of gardens were described by Sarangadhara, Vatsyayana, Surapala, and Chakrapani Mishra.

In Ramayana, Ashokavan in which Sita was held captive is mentioned. Ashoka trees (*Saraca asoca*) were predominant in this garden. In Panchavati, five trees were planted; *asvattha* (*Ficus religiosa*) on the east side, *bilva* (*Aegle marmelos*) on the north, *vata* (*Ficus benghalensis*) on the west, *amla* (*Emblica officinalis*) on the south, and *ashoka* on the southeast. A description of layout of gardens and parks and artificial lakes in the city of Indraprastha is given in the

Sabha-Parva of the Mahabharata. Several trees such as *Saraca asoca, Terminalia arjuna, Mesua ferrea, Ficus benghalensis, F. religosa, Michelia champaca, Butea monosperma*, and *Cassia fistula* have been mentioned in Ramayana. Almost all of them have been described in the Mahabharata. The association of Lord Krishna with the *kadamba* tree (*Anthocephalus cadamba*) is well known. Panini in Ashtadhyayi mentions several beautiful trees like *Ficus benghalensis, F. religiosa, F. infectoria, Butea monosperma, Prosopis cineraria* (syn. *P. spicigera*), *kadamba*, and a few others. The poet Ashvaghosha described the *nandanavana* in which Siddhartha saw flowering trees and lotuses. During the Buddhist period, gardens were laid out around the monasteries and stupas and there were beautiful gardens in Nalanda and Taxila. It is said that Lord Buddha was born under the pipal tree (*Ficus religiosa*) in a garden. The *bodhi* tree (*Ficus religiosa*), under which Buddha attained nirvana, is sacred to Buddhists. The trees and plants mentioned in Buddhist texts include *asvattha*, banyan, *udumbara* (*Ficus glomerata*), *patala* (*Stereospermum suaveolens*), sal (*Shorea robusta*), and *sirisa* (*Albizia lebbeck*).

Planting of roadside avenue trees (*margeshuvriksha*) was an important contribution of the Emperor Ashoka (304–232 BC). Similarly, King Shudraka (100 BC) has also given an account of gardens and flowers in the Mrichchakatikum. The famous playwright Kalidasa, perhaps the best naturalist of olden days, mentioned several trees, lotus, lilies, and climbing plants in his classics Kumarsambhav, Abhigyan, Shakuntalam, and Meghdootam. The poet Banabhatta in Harsha Charita presented description of trees, shrubs, and climbers like *arjuna* (*Terminalia arjuna*), *vata* (*Ficus benghalensis*), ixora (*Ixora arborea*), *Hibiscus* sp., etc. Kalidasa in his play Shakuntalam has mentioned the pleasure garden having a bower of the *madhavi* creeper (*Hiptage benghalensis*) and several beautiful trees like *ashoka* (*Saraca asoca*), *kadamba* (*Anthocephalus cadamba*), *arjuna* (*Terminalia arjuna*), *vakula* (*Mimusops elengi*), *palasha* (*Butea monosperma*), *parijata* (*Nyctanthes arbor-tristis*), and *kovidara* (*Bauhinia variegata*). The art of gardening has been described by Sarangadhara in his Upavanavinoda (1300 AD), wherein many trees have been mentioned. Vatsyayana (300–400 AD) has also rendered interesting accounts of four kinds of gardens, namely *parmadodyan, udyan, vrikshavatika*, and *nandanavana*.

With the renaissance of gardening in India by the Mughal rulers beginning with Babur, many plant species were brought by them from Persia and Central Asia where herbaceous and bulbous flowers were already under cultivation. Many of these have been mentioned in autobiographies and other books written during those days. Besides, in Mughal paintings also we find illustration of many flowers. These have also been used to illustrate the borders of those paintings. In the book Bagh-I-Wafa, Babur has presented a description of gardening in India.

During the 16th and 17th centuries Mughal gardens were developed in Agra, Delhi, Pinjore (near Shimla), Srinagar, and a few other places. The most important Mughal gardens are the Taj Mahal Garden, Agra; Shalimar and Nishat Gardens, Srinagar; Pinjore Gardens, Pinjore; and the garden of Humayun's tomb, Delhi. The rose was introduced in India via the port of Bussorah (Basra) by Babur around 1526 AD. Jahangir and Nurjehan were ardent lovers of the rose and

encouraged rose growing in gardens. The most important plants introduced in Kashmir from Persia by the Mughal ruler Jahangir in 1619, when he laid out the famous Shalimar Bagh in Srinagar, were the majestic *chinar* tree (*Platanus orientalis*), cypress or *sara* (*Cupressus sempervirens*), and the weeping willow (*Salix babylonica*), and flowers like, rose, narcissus, daffodil, iris, lilies, tulip, and carnation.

Native Indian Ornamental Plants

Trees

Albizia lebbeck, Alstonia scholaris, Anthocephalus cadamba, Azadirachta indica, Bauhinia variegata, Bombax malabaricum, Butea monosperma, Cassia fistula, C. nodosa, C. siamea, Erythrina indica var. *parcellii, E. variegata* var. *orientalis, Ficus religiosa, F. benghalensis, F. benjamina, F. elastica, F. lucescens* (syn. *F. infectoria*), *F. microcarpa* (syn. *F. retusa*), *Lagerstroemia speciosa, Michelia champaca, Milletia ovalifolia, Millingtonia hortensis, Mimusops elengi, Polyalthia longifolia, Pongamia pinnata, Pterospermum acerifolium, Putranjiva roxburghii, Rhododendron arboreum, Saraca asoca, Tecomella undulata, Terminalia arjuna, Thespesia populnea.*

Shrubs

Barleria cristata, Buddleia asiatica, Daedalacanthus nervosus, Dombeya spectabilis, Holmskioldia sanguinea, Jasminum sambac, J. grandiflorum, J. humile, J. officinale, Nyctanthes arbor-tristis, Russelia juncea, Spermadictyon suaveolens.

Climbers

Clematis paniculata, Clitoria ternatea, Ficus repens, Hiptage benghalensis, Porana paniculata, Thunbergia grandiflora.

Seasonal flowers

Amaranthus spp., *Celosia* sp., *Gomphrena* sp., lady's lace (*Pimpinella monoica*), *Torenia* sp.

Bulbous flowers

Allium giganteum, Canna sp., *Gloriosa superba, Iris* spp., tulips, orchids (*Alerides, Anoectochilus, Arundina, Calanthe, Coelogyne, Cymbidium, Dendrobium*).

Other plants

Lotus (*Nelumbo nucifera*), *Nymphae* spp. (*N. nouchali, N. stellata*).

Indoor foliage plants

Aglaonema sp., *Asplenium nidus, Begonia rex, Coleus blumei, Pilea cadieri, Pteris ensiformes.*

Indoor flowering plants

Crossandra infundibuliformis, Gynura aurantiaca, Kalanchoe blossfeldiana.

Diffusion of Ornamental Plants

During the 18th century, mainly the Englishmen and the Portuguese, introduced many plant species. Missionaries and priests, civil servants, and individual amateur gardeners brought these to India. One of the important missionaries who introduced a number of exotic plants was Dr Firminger, an Englishman, who wrote a book entitled "Firminger's Manual of Gardening in India", which is an authoritative reference book on ornamental flowering plants even today.

Further, with the establishment of several Government gardens by the British rulers during 18th and 19th centuries a number of ornamental trees and flowering plants were introduced in the country from abroad.

Several of the native flowers, particularly the attractive flora of the Himalayas including many alpine species, have been introduced into other countries. During the early British period in India, when some famous gardens were being developed in Great Britain, several plant collectors came to India in search of beautiful wild flowers. The wealth of Himalayan flora was introduced into England in the early part of the 20th century.

Questions

1. The art of gardening and kinds of gardens were described by:
   (i) Surapala (ii) Vatsyayana (iii) Varahamihira (iv) Kashyapa
2. Planting of avenue roadside trees was an important contribution of:
   (i) Kautilya (ii) Ashoka (iii) Vikramaditya (iv) Kanishka
3. Which of the following scholars described gardens in their writings?
   (i) Kalidasa (ii) Shudraka (iii) Vatsyayana (iv) Chavundaraya
4. The majestic *chinar* (*Platanus orientalis*) was introduced into Kashmir by:
   (i) Akbar (ii) Humayun (iii) Shahjahan (iv) Jahangir
5. Which of the following seasonal flowering plants are native to India?
   (i) Amaranthus (ii) Celosia (iii) Phlox (iv) Petunia

CHAPTER 15

PLANT PROTECTION

In ancient period the only method to protect the crops were prayers and chanting 'mantras'. This does not mean that Indians were not aware of insects and pathogens and the damage caused by them. Some of the pests affecting crops were named in Sanskrit like *gandhi*, *shankhi*, *pandarmundi*, *dhuli*, *shringari*, etc. It is certain that *gandhi* (offensive odor/smell) was what is called today the Gandhi-bug (*Leptocorisa varicornis*); *shankhi* must be a snail; *pandarmundi* means white head which is a typical symptom of the attack of rice stem borer. Similarly *dhuli* means powder and this word must have been used for powdery mildew of wheat and barley. The word *shringari* indicates something adorned with red color and it is possible that the term was used for rust diseases. Besides these, *kumari* and *madaka* also have been mentioned in ancient literature. Normally *kumari* means virgin. One can stretch the meaning to suggest seedling mortality or death before producing seeds. If the word *kumari* is broken into *ku* and *mari*, the meaning then would be a bad epidemic resulting into death of large number of plants. Likewise while there is no specific meaning of the word *madaka*, it is possible that this could be a variant of *marak* (the killer) and in that case the word would again carry the meaning of an epidemic. Both *kumari* and *madaka* may, therefore, be the diseases which often appeared in epidemic proportions. These could be the fungal diseases such as blast of rice, Helminthosporium blight of rice, and red rot of sugarcane.

Besides insects and diseases, goats, deers, rats, wild boars, pigs, and sparrows were recorded as the destroyers of crops.

The history of India reveals that the country has seen many ups and downs. Vedas are the world's oldest literature containing knowledge of science, art, culture, philosophy, astrology, astronomy, and religion. As mentioned in Chapter 2 (Sindhu-Saraswati Civilization), in the medieval period when foreigners attacked and conquered, they started destroying Indian literature, and even took away some of the scientific and other literature with them. The Indian literature is still present in many countries, which needs to be traced. An example of Vrikshayurveda may be quoted in this regard. This text was traced in the Bodleian Library of Oxford University, England.

Plant Protection in Vrikshayurveda

In Vrikshayurveda, Surapala (c. 1000 AD) has given plant protection techniques in a very systematic manner right from seed treatment to the storage of grains. Therefore, this period may be considered as the starting point of systematic plant protection in Indian agricultural history.

Ailments described by Surapala

Diseases of all kinds of trees are stated to be of two types: internal and external. It is unfortunate that all textbooks on plant pathology give credit to the French botanist, Tournefort (1705 AD), for

classifying diseases – internal and external. This was more than 700 years after Surapala had already done such a classification. The internal ones are caused by the imbalance of *vata*, *pitta*, and *kafa*; and external ones are caused by insects, cold weather, etc. Among these the diseases caused by *vata* are due to the land that becomes arid on account of excessive supply of dry and pungent matter. This leads to thinness and crookedness of trunk, appearance of knots on trunk and trees, and the fruits become hard with less juice and less sweetness.

The diseases of *kafa* type occur in winter and spring if the trees are excessively watered with materials which are sweet, oily, sour, or cold. Affected trees take long time to bear fruits, show paleness, dwarfing of leaves, tastelessness, and pre-maturity.

The diseases of *pitta* also occur at the end of summer if trees are excessively watered with materials which are bitter, sour, salty, and strong. These diseases are characterized by yellowness of leaves, dropping of fruits, dryness, paleness of flowers and fruit, and decay.

If the trees are exposed to scorching heat, or the roots are eaten by insects, this results in drying, yellowness, and excessive paleness of the leaves. The excessive stormy winds then cause stress which results in breaking, uprooting, and twisting of the trees. The break is of two types – one when branches break partially and remain attached to the tree and the other when they fall off. The trees also dry up due to exposure to fire or lightning as well as due to acidity of the soil and absence of water. When struck with an axe, etc. the trees are wounded resulting in drying up of all types of trees.

Due to imbalance of the *kafa* element, the trees ooze out even without wounds. If wrong treatment is given corresponding disease of the *vata* type results. Due to *vata* type of diseases day by day the trees lose their leaves, flowers, and fruits. The same results occur due to excessive watering, exposure to heat or due to wrong type of soil, and unfavorable seasons.

The imbalance of *vata*, *pitta*, and *kafa* enhances the disease of jaundice (yellowing). The trunk, fruit, and leaves of trees affected by the disease turn yellow. An imbalance in *vata*, *pitta*, and *kafa* develops due to faulty seed, lack of treatment, and wrong treatment, and renders all the trees unproductive.

Due to the attack of ants and due to the "indigestion" caused by excessive water the trees suffer from bad smell, lack of original fragrance, and dwarfing of leaves and sprouts. Fire, wind, friction with other trees, constant existence in shade, inhabitation by too many birds, excessive growth of creepers, and growth of weeds nearby – all these destroy the trees.

It is interesting to note that no attempt was made in the world by which plant disorders were classified into two groups – internal and external – before the time of Surapala. Further it is very significant that physiology of trees was considered similar to those of humans and therefore, the internal disorders were classified into *vata*, *pitta*, and *kafa* types as had been done in case of humans, that is the *tridosha* principle. Many symptoms described by Surapala can be attributed today to diseases caused by fungi, bacteria, or nematodes. In addition, damage due to other non-

infectious causes (external) such as excessive heat, frost, mechanical injuries, drought or waterlogging, birds, excessive growth of creepers, and competition by weeds was recognized.

Treatments of ailments suggested by Surapala

Diseases caused by *vata* can be cured by flesh, marrow, and ghee (clarified butter); sprinkling of *kunapa* water; and liberal fumigation of the mixture of fat of hog, oil of Gangetic porpoise, ghee, hemp, hair of horses, and cow's horn – boiled and set to a decoction. Likewise diseases caused by *kafa* can be cured with bitter, strong, and astringent decoction made of *panchamula* (roots of five plant species – *Clerodendrum phlomoides, Aegle marmelos, Stereospermum suaveolens, Gmelina arborea,* and *Oroxylum indicum*) with fragrant water; or the paste of white mustard (*Brassica alba*; syn. *Synapis alba*) should be deposited at the root and the trees should be watered with a mixture of sesame and ashes. In case trees are affected by the *kafa* disease, soil around the roots of the tree should be removed and fresh dry soil should be replaced for curing them. For *pitta* type of diseases, trees should be treated with cool and sweet substances; trees should be watered with decoction of milk, honey, *yashtimadhu* (*Glycyrrhiza glabra*), and *madhuka* (*Madhuca indica*). Further, when watered with the decoction of fruits of *triphala* (the three kinds of myrobalan – *Terminalia chebula,* T. *bellirica,* and *Emblica officinalis*), ghee, and honey, the trees are freed of all diseases of *pitta* type.

To remove insects both from the roots and branches, the trees should be watered with cold water for seven days. The worms can be overcome by the paste of *kunapajala* (fermented product) and cow dung mixed with water and also by smearing the roots with a mixture of white mustard, *vaca* (*Zingiber zerumbet*), *kusta* (*Saussurea lappa*), and *ativisa* (*Aconitum heterophyllum*). Likewise the insects on the leaves can be destroyed by sprinkling the powder of ashes and dust. A wound caused by insects heals if sprinkled with milk after being anointed with a mixture of *vidanga* (*Embelia ribes*), sesame, cow's urine, ghee, and mustard. Other wounds of the trees are healed by anointing with the paste of bark of *nyagrodha* (*Ficus benghalensis*), and *udumbara* (*Ficus glomerata*), cow dung, honey, and ghee. The oozing can be cured by smearing this paste and covering the part with the bark of *dhava* (*Anogeissus latifolia*), *sriparnika* (*Myrica esculenta*), *syama* (*Ichnocarpus frutescens*), *vetasa* (*Salix caprea*), and *arjuna* (*Terminalia arjuna*).

Similarly Surapala had suggested different treatments like sprinkling of *kunapajala* and milk on trees damaged by fire and anointing the branches of trees with *vidari* (*Pueraria tuberosa*), sugar, *nagajivha* (*Enicostemma axillare*), and sesame mixed together and sprinkled with milk-water on the trees suffering from lightning damage. Further, if the trees dried due to bad soil, the original soil from the root should be removed and it should be replaced by healthy soil and milk-water should be sprinkled on it. If the drying is due to lack of water the trees should be watered with milk-water and properly fomented by the smoke of crab shells.

Diseases caused by wrong treatment can be overcome by sprinkling the mixture of water and milk and also by applying a paste of *vidanga (Embelia ribes)* mixed with thick mud. Jaundice

(yellowing) can be brought under control only in weeks by sprinkling water mixed with the powder of barley and wheat added to honey and milk.

Infectious Diseases

Surapala suggested that before planting cuttings in the pits, the latter should be 'burned' using dry plant material, cow dung, etc. This is an indication of a suspicion that Surapala must have had about existence of infectious entities. Chakrapani Mishra (1577 AD) suggested that diseased plants found in the midst of healthy plants should be uprooted and burned, again pointing towards existence of infectious entities. It is unfortunate that all the current textbooks on plant pathology credit Tillet, who in 1755 AD dusted wheat seed with 'bunt' spores to produce the disease called wheat bunt. We should, however, know that Koch's postulates have to be followed to prove infectious nature of a disease. Here again, Indians have not been given due credit by the authors of the West.

Vishavavallabha is another treatise written by Chakrapani Mishra under the patronage of Maharana Pratap of Mewar on the science of plant life which resembles Surpala's Vrikshayurveda and deals more or less with the same subject but with some additions. For example, several new herbs have been mentioned for the control of disorders; such plant species are: *ambu* (*Pavonia odorata*), *aragavadha* (*Cassia fistula*), *arishta* (*Sapindus emarginatus*), *ingundi* (*Nalanites odorata*), *karanja* (*Pongamia pinnata*), *katphala* (*Myrica esculenta*), *katvanga aegyptiaca*), *karanja* (*Pongamia pinnata*), *katphala* (*Myrica esculenta*), *katvanga* (*Ailanthus excelsa*), *kuberakshi* (*Caesalpinia crista*), *nimba* (*Azardirachta indica*) (bark), *rohita* (*Tecomella undulata*), *shatapushpa* (*Anethum sowa*), *tagara* (*Valeriana jatamansi*), *vasa* (*Adhatoda vasica*), etc.

Apart from Vrikshayurveda and Vishvavallabha paramount documents concerning plant protection were Someshvardeva's Manasollasa (1131 AD), Sarangadhara's Upavanavinoda (1300 AD), Bhavaprakasha Nighantu (c. 1600 AD), Tuzuk-i-Jahangiri (1605–1627 AD), Dara Shikoh's Nuskha Dar Fanni-Falahat (1650 AD), Jati Jaichand Diary (1658–1714 AD), an anonymous Rajasthan manuscript (1877) from Mewar region of Rajasthan, and Watt's Dictionary of Economic Products of India (1889–1893).

Jahangir, the Mughal Emperor of India (1605–1627) described in his memoir a disorder of marigold which could be ascribed today to species of *Alternaria*, *Botrytis*, or *Sclerotium*. Similarly in Jati Jaichand Diary, the early blight (*Curvularia penniseti*) of pearl millet and possibly Botrytis gray mold of chickpea have been described.

In a document of early 19th century from the Mewar region of Rajasthan, powdery mildew has been described on various plants; also canker or anthracnose of orange is mentioned. In this document several plant protection practices have been given. Some interesting practices are:

- Use of oil (probably sesame) for soil and foliar application to trees to protect from frost and termites.
- Sprinkling of curd (9 L) with asafetida (112 g) on trees to prevent powdery mildew.

- Use of asafetida and *vidanga* (*Embelia ribes*) mixed with curd every 10 days to protect against canker of orange.

Use of cow dung for smearing the cutting of fig before planting is mentioned in Dara Shikoh's Nuskha Dar Fanni-Falahat. Garlic has been mentioned specially for insect control. In addition to these he has mentioned the use of salt solution for soaking fig cuttings before planting. This is followed by cow dung application.

Indigenous Plant Protection Practices Still Followed

In traditional agricultural practices, farmers evolved an effective system of crop protection through generations of experience and intimate knowledge of their environment. Some of these indigenous practices are still followed by the farmers in different parts of the country.

Plant protection in Arunachal Pradesh

Several indigenous practices of plant protection such as folklore, rituals, use of plant extracts, storage management, etc. are still followed in Arunachal Pradesh. Some of these are given below:

- Buttermilk for pest control: Farmers treat garlic seeds with buttermilk at 10–12 L ha^{-1} before sowing for protection against different diseases and insect pests.
- Asafetida to control ergot of sorghum: Asafetida (50–60 g) is mixed in water and the solution is used to treat sorghum seeds for protection against ergot.
- Control of ginger rot and yellowing: The tribal farmers sow ginger after treating with a solution of cow dung. About 10–15 kg cow dung and asafetida (40–80 g) are mixed in 8–10 L of water. This is enough to treat ginger rhizomes required for one hectare. This practice is helpful for protecting ginger plants from rotting during vegetative growth. To prevent yellowing the farmers grow papaya as an intercrop for providing shade to ginger. The leaves of ginger do not turn yellow and high yields are obtained.
- Control of tomato wilt: Farmers use turmeric powder at 15–20 kg L^{-1} of water to control wilt (*Fusarium* sp.) of tomato. This solution is used to treat the roots of seedlings in tomato nursery before transplanting.
- Control of early stem borer in sugarcane: To control stem borer (*Chilo infuscatellus*) in sugarcane farmers use neem oil at 1.5–2 L ha^{-1}. This practice is repeated thrice in the whole period of sugarcane vegetative growth.
- Control of termites: Farmers keep asafetida in a pack of cotton cloth at two or three points in the irrigation channel of 10–15 m for controlling termites (*Odonotermes* spp.) in affected crops.
- Control of storage pests: Farmers use different simple practices for effective control of storage pests; viz., fuel wood ash at 250 g for 250 kg of pulses; dry neem leaves at 2.5 kg for 100 kg of wheat; and five to six dry chilies placed in one kg seed of mung bean and black gram.

Plant protection in Rajasthan – Semi-arid region

Gaur *et al.* (2002) (see Agricultural Heritage of India) reported the following methods of plant protection used by farming communities in the semi-arid region of Rajasthan.

- Control of termites:

– Termites attack and cracking of epidermis in fruits can be avoided by using a paste on the main trunk with a mixture of mustard oil (1 L) and turmeric powder (200 g). Mustard oil attracts ants which remove termites while turmeric powder helps in healing the cracks. In another practice, *aak* (*Calotropis* spp.) leaves are chopped, filled in gunny bags, and kept in irrigation channel. The exudates from these leaves have been reported to kill termites and other soilborne pathogens.
– Farmers amend the soil with the pre-incubated mixture of *aak* leaves (5 bags), neem kernels and leaves (95 bags), and asafetida (200 g) to check termite attack in the field and soilborne diseases. Farmers claimed good growth of crops due to this amendment.

- Control of *Helicoverpa:*

– To control *Helicoverpa* in chickpea farmers followed a typical bio-control method. Pearl millet grains or pieces of *chapatti* (thin unleavened bread) soaked in buttermilk are scattered in chickpea field to attract birds, which in turn predate on *Helicoverpa* larvae. Further, neem leaves and kernels are being commonly used to control the pest (*Helicoverpa*) on cotton and chickpea in some areas.
– Spraying of extract obtained by crushing together garlic, onion, and chili after dilution also effectively controls *Helicoverpa* pests of vegetables.

- Control of thrips, aphids, whitefly, and other pests:

– To prevent thrips and aphids, cow dung ash is applied on foliage of vegetables, e.g., chili, onion, garlic, and cucurbits.
– To trap insects like whitefly and thrips, spraying of buttermilk over cucurbits and chili plant is a common practice in some districts of Rajasthan.
– In Jodhpur district some farmers use cow urine based biopesticide to check whitefly, jassids, and other sucking pests of chili and cumin (*jeera*). This is prepared by mixing cow urine (10 L), neem kernel and leaves (2 kg), and garlic (50 g). The ingredients are crushed and kept in a copper container for 15 days. The solution is then heated till 5 L of solution is left. After cooling, the liquid is filtered and diluted with 500 L of water before spraying. The farmers even claimed its efficacy in controlling viral diseases of chili.

- Control of nematodes:

– A mixture of cow dung, leaves of *aak* (*Calotropis* spp.), foliage of *kheip* or *khip* (*Crotalaria burhia*; a local xerophytic plant) is allowed to rot in a pit for about two months. This mixture

(manure) is then applied in chili and tomato fields for control of root-knot nematodes and termites and for good plant growth.

Plant protection in Rajasthan – Tribal region

Solanki and Sanadhya (2002) (see Agricultural Heritage of India) reported the following methods of plant protection used by tribal farmers in Rajasthan.

- In paddy, a solution of 4 L of cow urine and 10 g asafetida in 10 L of water is sprayed to repel sucking pests (aphids and jassids).
- To control paddy blast and bacterial blight, farmers commonly spray a solution of cow dung prepared by mixing 3 kg cow dung in 3 L of water.
- In case of insect holes made by shoot borer and bark eaters in mango trees, jaggery is placed in the holes to attract other predators (ants), which will feed on the insects present in the holes. Farmers also pour kerosene in the insect holes or block the holes with cow dung.
- A peculiar method of controlling chili is practiced by tribals in which the twigs of *aak* (*Calotropis* spp.) are placed in between rows. Some farmers place fresh cow dung near the collar region of chili plant to prevent it from fungal diseases, viz., damping-off and die-back.
- In case of soilborne diseases such as root rot and collar rot, and termite attack, castor, *karanja* (*Pongamia pinnata*), or neem cakes are used as control measures.
- During sprouting of sugarcane sets the stem of *aak* (*Calotropis* spp.) is placed in the irrigation channel during intercultural operations. This is effective against termites.

Plant protection in tea estates in Northeast India

Recently, based on Surapala's Vrikshayurveda, Valmiki Sreenivasa Ayangara used different preparations, viz., *Panchagavya, Chimmigavya, Dhanyagavya, Indsafari*, etc. having effective insecticidal and fungicidal properties against tea bushes in Northeast India (see Chapter 16, *Kunapajala*: Liquid Manure).

Control of tea mosquito bug (*Helopeltis theivora*). The method followed at Deckiajuli Tea Estate, Assam is given below.

To prepare a decoction, fresh leaves of *Vitex negundo* and *Clerodendrum serratum* were chopped into small pieces and filled up to the brim in a 200 L barrel. Then raw cow dung (20 kg) and molasses (2 kg) were added to it and the barrel was filled with water up to the top and stirred well. The barrel was closed with the lid and allowed to ferment for 12–15 days. It was filtered and used in desired concentrations.

This decoction was found very effective against *Helopeltis* at all concentrations. Spraying at weekly intervals at 2% concentration controlled this dreaded pest in tea plantation.

Scientific Basis of Age-old Plant Protection Practices

It has been now realized that the techniques adopted for commercial agriculture are unsustainable in long term. Therefore, agricultural scientists are diverting their attention to the traditional or

indigenous technology and exploring possibilities of using them wherever possible. Our old traditional technologies were scientific and almost eco-friendly as all the plant protection practices were based on organic materials both of plant and animal origin which includes honey, ghee (clarified butter), milk and milk products, cow dung and urine, and several plant species like *Brassica* spp., *Madhuca indica*, *Ficus* spp., *Piper nigrum*, *Azadirachta indica, Vitex negundo*, *Embelia ribes,* etc. Recent biochemical analysis of these materials clearly indicate that all these materials have antimicrobial activities.

Milk and ghee have been used for centuries. Even buttermilk was found useful. About 40% of total amino acids in milk are glutamate, leucine, and proline. A recent report claimed that milk sprays induced systemically acquired resistance in chili against leaf curl, a viral disease. Milk (10% aqueous suspension) has also been effectively used for controlling powdery mildews.

The use of cow dung by our farmers for different purposes like seed dressing, plastering cut ends of vegetatively propagating units such as sugarcane sets, dressing wounds, sprinkling dilute suspension of plants and applying to soil has been indicated since the time of Kautilya (321–296 BC). The cow dung from the cattle shed is a mixture of dung and urine in a ratio of 3:1. Cow dung consists of crude fiber, crude protein, and materials that can be obtained in nitrogen-free extracts. There are more than 60 species of bacteria and 100 species of protozoa encountered in the rumen of cow. Thus when seed is treated in various ways with cow dung, it gets coated with cow dung residue. The residue contains several elements, enzymes, macro- and micronutrients, epithelial cells, bile salt and pigment, and large number of bacteria. The dung residue has emulsifying properties and readily absorbs moisture from the surrounding soil to the advantage of seeds. The presence of bacteria may antagonize potential pathogens ready to attack seed.

Neem (*Azadirachta indica*) leaves contain Nimbidin and on hydrolysis it produces nimbidinic acid due to presence of sulfur which prevents storage insect pests. Besides this two other bitter compounds free from sulfur are also present which give a characteristic unpleasant smell. Hence dry leaves are very effective and commonly placed in books and clothes to protect them from moths, etc. The odor produced by burning powdered neem leaves is fatal to insects.

Application of neem cake to the field reduces population of soilborne fungi and nematodes and also reclaims alkaline soil due to presence of calcium and magnesium. The old practice of spreading neem leaves over stored groundnut has a scientific basis. It has now been proved that neem leaves inhibit the growth of *Aspergillus flavus* and thereby prevent aflatoxin production.

The utility of neem tree has been recognized long back in Indian agricultural history. Every part of this tree is used for several different purposes. This tree is now found to be an effective air filter and protects the environment.

Questions

1. Which of the following have been mentioned as pests by Parashara?
   (i) *Pandarmundi* (ii) *Shankhi* (iii) *Jhulsa* (iv) *Parnakunchan*
2. Who was the first to classify plant diseases as internal or external?
   (i) Tournefort (ii) Adolf Meyer (iii) Surapala (iv) Chakrapani Mishra
3. Who was the first person to have suspected presence of infectious diseases in plants?
   (i) Chakrapani Mishra (ii) Tillet (iii) Millardet (iv) Kashyapa
4. Who was the first Indian physician who used the *tridosha* (*vata*, *kafa*, and *pitta*) concept of Ayurveda to trees?
   (i) Varahamihira (ii) Surapala (iii) Parashara (iv) Kashyapa
5. Which of the Mughal emperors described a disorder of marigold?
   (i) Akbar (ii) Jahangir (iii) Shahjahan (iv) Prince Dara Shikoh

CHAPTER 16

KUNAPAJALA: LIQUID MANURE

In Vrikshayurveda, written by a physician Surapala about one thousand years ago, *kunapa* has been mentioned as liquid manure. In verses 101 to 105 Surapala describes: "The excreta of marrow of bones, and flesh, brain and blood of a boar mixed with water and stored underground is called *kunapa*. As per availability the fat, the marrow and flesh of the fish, the ram, the goat and other horned animals should be collected and stored. These should be boiled after mixing with water, and the mixture should be stored in an oiled pot after adding sufficient quantity of husk (not mentioned clearly but probably paddy). After roasting it in an iron pot, sesame oil cake and honey should be added. Soaked black gram of good quality should also be added. A little ghee (clarified butter) should then be poured. The items stated above should be taken at random as there is no measure for anything. One by one it should be placed in the pot in a warm place by a competent person."

Surapala further quoted that "this *kunapjala* is highly nourishing for trees. This is stated by the ancient sages and I (Surapala) repeat it here after verifying the same."

Sarangadhara (1283–1301 AD) was a scholar in the court of King Hammira of the present-day Bundelkhand. The verses 171–174 of Sarangadhara's Upvanavinoda deal with *kunapajala*. One should boil the flesh, fat, marrow of deer, pig, fish, sheep, goat, and rhinoceros in water and when it is properly boiled one should put the mixture in an earthen pot and add into it the compound milk, powder of sesame oil cake, black gram boiled in honey, the decoction of pulses, ghee, and hot water. There is no fixed measure as to the amount of these materials. When the said pot is kept in a warm place for about a fortnight, these materials are transferred into a compound called "*kunapajala*" which is very nutritive for plants. Although the materials used by him were almost the same as those used by Surapala, Sarangadhara indicated that any material waste can be used for the preparation of *kunapajala*.

Chakrapani Mishra (1577 AD) compiled "Vishvavallabha" in which *kunapajala* is described. According to Chakrapani, fat, marrow, blood, and skin of ram, sheep, deer, and fish should be mixed with water and cooked in fire. When properly cooked, milk and cold water should be added. Oil cake of sesame, honey, and ghee should be added to the mixture and the pot should be removed from fire and kept in a warm place for a fortnight. This liquid called *kunapajala* is very nourishing to trees. It is interesting to note that the main constituents of *kunapajala* are almost the same with slight variations.

Different Preparations of *Kunapajala*

After getting impressed by Surapala's Vrikshayurveda, Valmiki Sreenivasa Ayangarya who is basically a mathematician, decided to use the techniques given in Vrikshayurveda. Recently, he

developed Herbal *Kunapa* (*Kunapajala*) from the plants, which are considered either unwanted or called weeds in the modern agriculture and are destroyed under weed management system. He not only prepared *Kunapajala* but also studied its efficacy particularly on tea in Northeast India. Some of the preparations are given below.

Panchagavya

Panchagavya means five products of cow. These are cow dung, cow urine, milk, curd, and ghee. *Panchagavya* is used in different religious ceremonies. The fermented product of all these five products of cow is very nutritive for plants; however, Ayangarya used *Chaturgavya;* i.e., four products of cow, namely, dung, urine, curd, and milk. This *Chaturgavya* was found to rot quickly because ghee delays fermentation. *Chaturgavya* used at 2–3% concentration, acts as an insecticide, growth promoter, and soil conditioner. Because this preparation undergoes fermentation, it is a mistake to call it "*Panchagavya*"; the latter is used fresh according to *shastras.*

Sasyagavya

Sasyagavya is prepared by chopping the leaves of the plants locally available in plenty and fermenting them in water along with cow dung. To prepare *Sasyagavya*, the chopped leaves are filled in a container up to the brim and then cow dung is added. The container is filled with water and covered with the lid. It is kept in a warm place for 10–15 days. The mixture is stirred 2–3 times daily. The ratio of cow dung, leaves, and water is generally 1:4:10.

Dhanyagavya

Dhanyagavya is made by fermenting paddy husk in cow urine or cow dung and water at least for one month. The mixture is stirred twice a day. The end product has 0.35% silica in soluble form when prepared with cow dung but when prepared with cow urine the quantity of soluble silica is 0.19%.

Indsafari

As per Vrikshayurveda, the animal products are boiled for the preparation of *kunapajala*. The *Indsafari* is a *kunapajala* prepared by using dead fishes which are discarded by the fishermen. In this preparation the fishes along with cow dung and water are fermented for 2–3 days only. No cooking is required. *Indsafari* can be used with *Sasyagavya* for soil drenching as well as foliar spray with functions both as growth promoter and as insecticide.

Preparation of Herbal *Kunapajala*

Materials required

- Container of 20 L capacity with lid
- Cow dung one kg
- Fresh chopped leaves (locally available weed plants or other plants) 4 kg
- Molasses/cane jaggery 100 g

- Sprouted black gram seeds 100 g
- Water 10 L

Method of preparation

- Fresh and green leaves of weeds or other plants are chopped and kept in the container.
- Molasses/cane jaggery, cow dung, and sprouted black gram seeds are added.
- Water is then added.
- The mixture is stirred well.
- The lid is then closed.
- The container is kept in a warm place for 10–12 days.
- The mixture is stirred 2–3 times daily to release the gas formed.
- The preparation is used when it stops producing gas.
- It is filtered and then used.
- The solution is used at 1 to 2% concentration or in pure form depending on the condition of the plants.

Recently, "*Gunapajalam*" (*kunapajala*) prepared by RS Narayanan of Tamil Nadu from animal products was found very effective in increasing crop yield. Appreciating the effectiveness of *kunapajala*, the Government of Tamil Nadu recommended the use of the preparation to farmers of the state.

Thus we see that the technology developed by our ancestors is of importance in the present time where the extensive and indiscriminate use of chemicals are polluting our soils and environment.

Questions

1. The first scholar who described *kunapajala* was:
   (i) Varahamihira (ii) Surapala (iii) Sarangadhara (iv) Chakrapani Mishra
2. What is the main ingredient of *kunapajala* in ancient texts?
   (i) Flesh and bones (ii) Cow dung and urine (iii) Some herbs (iv) Sheep excreta
3. Which of the following cow products are present in fermented *Panchagavya*?
   (i) Milk (ii) Dung (iii) Flesh (iv) Horn
4. *Indsafari*, a *kunapajala* variant, contains:
   (i) Cow dung (ii) Some Indian herbs (iii) A fish (iv) Animal wastes from a zoo
5. *Kunapajala* is used for:
   (i) Protection of plants (ii) Dwarfing of plants (iii) Nourishment of plants (iv) Killing weeds

CHAPTER 17

FAMINES AND FAMINE-FOOD

The dictionary meaning of famine is the extreme scarcity of food. The Indian subcontinent has often been subjected to famines. Our ancestors were well aware of famine and drought. Reference of famines/droughts has been made in Rigveda. They considered these disasters as a result of anger of their gods such as Indra, Varuna, and Agni. Therefore, they used to perform "*Yagna*" to propitiate their gods.

The famines in the Indian subcontinent right from 5th century BC to 18th century AD are listed in Table 1. It is evident from the table that from 5th century BC to 10th century AD (1500 years), there were five famines only whereas from 11th century to 18th century AD (800 years), there were 51 famines.

Causes of Famines

The factors responsible for famine can be grouped under two categories: (1) natural; and (2) man-made.

Natural factors

Drought, floods, rainfall, storms, earthquakes, and crop pests are the major factors for causing famine.

Drought. Famine due to drought was known to our ancestors; therefore, they studied the pattern of rainfall and developed techniques of rainfall prediction. Rigveda seers noticed that "*Marutganas*" (which bring rains) starting from Southeast moved over thousands of "*yojanas*" (1 *yojana* = 8 miles or 12.8 km) of land shedding rains before reaching the western regions of the country where they become weak.

It has now been established by the modern science that Southwest winds cross the vast water table of the Arabian Sea, pick up enormous quantity of water during their passage over the sea, and then strike the western coast of the country and flow over Deccan plateau shedding rains. These winds then move to Bay of Bengal. Due to various geographical factors including trade winds which serve as obstacle, these winds turn back to eastern coast and cross Orissa, Madhya Pradesh, eastern Rajasthan and reach right up to the Indus (Sindhu) river lying on the western periphery of Punjab plains. During this journey the strong winds laden with enormous moisture shed rains on the eastern coast and Central India. These winds then become weak, and their moisture content is reduced, when they reach the western states like Gujarat, Rajasthan, and Punjab. Hence the rainfall in these regions is irregular, scanty, and erratic. Therefore, these regions are famine prone, and the frequency of famines is high. On the other hand, the frequency of famine in Karnataka, Kerala, and

Assam is far less due to their geographical location and the intensity of monsoon activity. Thus we see that the path of Southwest monsoon recognized by our ancestors thousands of years ago holds true even today.

Majority of famines that occurred in the Indian subcontinent were due to drought, i.e., failure of monsoon. Rajasthan and Gujarat had been the most affected states. These two states have faced 51 famines due to drought from 5th century BC to 18th century AD (Table 1). In 1257 AD there were no rains in Gujarat which resulted in severe famine. From 1460–1471 AD, famines occurred in several parts of India including Orissa and Assam due to failure of monsoon rains. In 1770 AD, the worst famine was seen in Bihar, Orissa, Assam, and Bengal. In these regions there were no rains in rainy season. Death toll due to famine in Bengal ranged from 3 million to 10 million. The area affected was about 336,000 km^2 and about 30 million people of these states suffered a lot due to this famine.

Floods. Excess rains in the catchment area of the rivers caused floods in the rivers. The famines due to floods are generally seen in the plains. In Gujarat, famine due to floods was seen in 443 BC. In the 11th century AD, heavy floods in Ganga and Yamuna rivers resulted in famine in Delhi, Bihar, and Bengal. In 1768 AD famine was noticed in Delhi, Gujarat, and Maharashtra due to floods.

Storm. Severe famines were seen during 1291 to 1295 AD in Gujarat and Maharashtra due to storms in the beginning of rainy season leading to uprooting of trees and destruction of buildings. No crops could be taken during this period which resulted in the severe scarcity of food.

Volcanoes and snowfall. Few famines were observed due to eruption of volcanoes and snowfall. Eruption of volcano occurred in Kashmir causing severe famine in 443 BC. In the 1st century BC heavy snowfall in Kashmir destroyed the standing crop of rice resulting in famine.

Man-made factors

Greed, rapacity, ruthlessness, etc., which make the human existence more miserable are the man-made factors that cause famine.

As described earlier, there were only 5 famines from 5th century BC to 10th century AD. The frequency of famines increased thereafter. The reason attributed to this fact was political instability. After 10th century AD, invasion of Turks and Mughals from the West began. There was a marked increase of wars in which the standing crops were destroyed and the food granaries were looted by invaders rendering the local public to starve. After Turks and Mughals, the British stepped in and continued wars and diverted a major part of food grains and other commodities for their own people and soldiers. Thus there was severe scarcity of food for the general public of the country leading to man-made famine.

Table 1. A chronological list of famines in the Indian subcontinent during the 5th century BC to 18th century AD.

Period	No. of famines	Region of famine[1]	Reasons/Remarks
5th century BC	1	Famine in 1 year.	
443 BC		Kashmir, Ayodhya (eastern Uttar Pradesh), Rajasthan, Gujarat, Maharashtra, and Punjab	Eruption of volcanoes in Kashmir; drought in Punjab; floods in Gujarat; and rainfall deficit in Rajasthan.
1st century BC	1	Famine in 1 year out of 37 years. The specific year is not known.	
103 BC to 66 BC		Kashmir	King Tunjina reigned during this period. Heavy snowfall in September–October destroyed the standing rice crop.
9th century AD	1	Famine in 1 year.	
857		Kashmir	Heavy floods (Source: Rajatarangini by Kalhana).
10th century AD	2	Famines in a 3-year period.	
917		Kashmir and Punjab	King Partha was the ruler. Great mortality.
941–942		North India and North-West Frontier Province (NWFP) in Pakistan	Internecine local wars. Turk invasions reported in this period.
11th century AD	2	Famines in 2 years.	
1022		Delhi, Bihar, Bengal, Orissa, and Rajasthan	Floods in the rivers Ganga and Yamuna.
1099		Kashmir	
13th century AD	4	Famines in a 10-year period.	
1200		Orissa, Bihar, Assam, and Bengal	Failure of monsoon rains; and internecine wars.
1215		Rajasthan, Maharashtra, and Gujarat	
1257–1259		Severe famine in Gujarat which lasted 3 years	No rains in 1257; and rainfall deficit in 1258.
1291–1295		Severe famine for five years in Gujarat and Maharashtra.	Severe storm in the beginning of the rainy season, leading to uprooting of trees and destruction of buildings; and heavy rainfall causing floods.

continued

Table 1. *continued*

Period	No. of famines	Region of famine[1]	Reasons/Remarks
14th century AD	5	Famines in a 40-year period.	
1296–1317		Severe famine in Delhi.	Alauddin Khilji was the ruler.
1341–1342		Delhi, Rajasthan, Maharashtra, and Mysore	Mohammad Tughlakh was on the throne of Delhi at this time. Failure of rains and local wars.
1344–1345		Delhi	
1351		Delhi	A period of ten years from 1341 to 1351 described as years of God's displeasure.
1396–1408		Karnataka, Maharashtra, Rajasthan, Gujarat, and Delhi, and several other parts of India	Well-known as Durgadevi's famine.
15th century AD	4	Famines in a 5-year period.	
1412–1413		Areas near the rivers Ganga and Yamuna, and in Rajasthan	Failure of monsoon rains.
1460		Maharashtra	Failure of monsoon rains.
1471		Orissa and Assam	Severe drought.
1491		Most parts of India	Severe drought.
16th century AD	6	Famines in a 11-year period.	
1520–1521		Most of the Bombay Presidency and Sind (Pakistan)	Deficit in rainfall in Sholapur District; and foreign invasion and plunder in Sind (Pakistan).
1527		Punjab and Sind (Pakistan)	Sind (Pakistan) conquered by Mirza Shaha Bedai. So Jaminda, King of Sind (Pakistan) burned up all food-stocks to harass the enemy.
1540–1543		Severe in Maharashtra, Punjab, and Sind (Pakistan)	To meet the threat of Humayun's invasion, Mirza Shaha Hun, King of Sind, prohibited sowing of crops on the banks of Indus river and import of food grains from other parts. Rainfall deficit in Bombay Presidency. Transport of food grains by traders from Bombay Presidency to Punjab affected by famine.

continued

Table 1. *continued*

Period	No. of famines	Region of famine[1]	Reasons/Remarks
1556–1557		Delhi, Rajasthan, Punjab, and NWFP (Pakistan)	The Mughal emperor Akbar was the ruler.
1579		Kutch area (Gujarat)	Failure of monsoon rains.
1596		Central India	Effects of the famine felt all over Asia. As the administration of Akbar was efficient, South India was spared from this famine. Comet seen in the sky for 18 days before this famine.
17th century AD	6	Famines in a 23-year period.	
1628–1629		Gujarat	More severe than the one in 1596 as described by Elphiston. No rain during the two years.
1631		Maharashtra and Gujarat	Failure of crops. Effects of famine felt all over Asia.
1640–1655		Famine lasted for seven years in Gujarat. It spread to Maharashtra and Bengal later on. Maximum death toll of human beings in 1650–1652.	Invasions of Mughals from Delhi; and sudden rise in the number of plunderers and looters.
1661		Central India, Delhi, Punjab, and Bengal	Aurangzeb was the emperor. Crops destroyed in Bengal by locusts; Punjab and Delhi affected by droughts.
1677		Hyderabad region	Excessive rains. Great mortality.
1682–1683		Gujarat and Rajasthan	Failure of monsoon rains in Gujarat.
18th century AD	24	Famines in a 60-year period.	
1703		Bombay Presidency	Drought.
1718		Drought in Gujarat, Maharashtra, and Madras Province	Rainfall deficit in Gujarat; Faruk Shaha, Emperor of Delhi was ineffective and hence the people suffered.
1731		Gujarat, Rajasthan, and Punjab	Mughal power in Gujarat was weakened; military campaigns by the Marathas from the South; and scarcity of food grains.

continued

Table 1. *continued*

Period	No. of famines	Region of famine[1]	Reasons/Remarks
1732		Gujarat and Rajasthan	Failure of monsoon rains.
1733		Madras, Gujarat, Rajasthan, and NWFP (Pakistan)	Hindu Kings in Madras had constructed a number of tanks for water storage and agricultural cultivation. They were neglected by the Muslim rulers. Hence shortage of food grains.
1737		Rajasthan	
1739		Delhi, Gujarat, Maharashtra, and Madras	Nadir Shah of Persia looted Delhi in 1739.
1744 and 1745 to 1752		Two famines in this 9-year period in Gujarat	Failure of rains; excessive rains; floods; and political instability.
1757–1760		Sind (Pakistan), Gujarat, and different parts of India at different times	Normally no famines in Sind (Pakistan) because of availability of irrigation facilities. But in 1759, owing to local wars, there was shortage of food grains. The famines became severe due to wars between Marathas and the Mughals.
1761		Famine in Sind (Pakistan), Gujarat, and different parts of India at different times.	Defeat of the Marathas at Panipat made the position difficult.
1765		Bombay, Rajasthan, Gujarat, and Sind (Pakistan)	Failure of monsoon rains.
1766		Gujarat	
1768		Delhi, Gujarat, and Maharashtra	Floods.
1769		Bengal	Failure of rains.
1770		Bihar, Orissa, Assam, Bengal, and NWFP (Pakistan)	Worst famine in India in the 18th century. No rains in the rainy season. Death toll due to famine in Bengal varied from 3 million to 10 million. Area of famine – 130,000 sq. miles (336,700 km^2); population affected – 30 million.

continued

Table 1. *continued*

Period	No. of famines	Region of famine[1]	Reasons/Remarks
1773		Bombay Presidency	Failure of rains.
1774		Gujarat	
1781–1782		Bombay Presidency and Madras	Loss of food grains in Madras owing to Military Campaigns of Hyder Ali.
1783		Central India, Punjab, and NWFP (Pakistan)	
1783–1790		Famine-like conditions in Thar area (Pakistan)	1782–1783 famine in Gujarat spread up to North-East Frontier Province (NEFP) and from North of Bengal and Orissa up to Punjab. 1784–1786 famine in North India, Uttar Pradesh, and Bombay. Failure of rains, attack of crops by locusts, and local wars. One million killed in famine of 1785 in Punjab.
1787–1792		6 years of famine-like conditions in Hindustan (except Bengal, Orissa, and Uttar Pradesh), Madras, Bombay, Gujarat, Rajasthan, Punjab, Karnataka, Maharashtra, and NWFP	Attack of crops by locusts.
1787–1796		Maharashtra and Karnataka	Failure of rains; and attack of crops by locusts.
1794–1796		Maharashtra, Gujarat, and Bengal	1790–1791, loot by beggars in Gujarat.
1799–1801		Madras	

1. Punjab of India and Pakistan; Bengal is present-day West Bengal in India and Bangladesh; Bombay Presidency includes present-day Maharashtra, Karnataka, and Gujarat; Madras Province includes present-day Tamil Nadu

In the 14th century, war took place between Alauddin Khilji and Mohammad Tughlakh. In this war crops were destroyed which led to severe famine in Delhi. In the 16th century, Mirza Shah Hun, the King of Sindh prohibited sowing of crops in the bank of Sindhu river to meet the threat of Humayun's invasion. Although food grains were imported these were used by the Royal family and soldiers and the general public was left to starve. In 1731 AD when Mughal power weakened, the Marathas

from South attacked the Mughal territory of Gujarat. The war destroyed the crops. The Muslim rulers in Madras abandoned the irrigation system of tanks built by Hindu kings. The crop production gradually reduced and then there was famine in the year 1733. During 1781–1782 extreme shortage of food grains occurred in Madras due to Hyder Ali's military campaign.

Our ancestors did not recommend construction of big dams but in modern times man has constructed huge multipurpose dams for irrigation and hydro-electric power where enormous amount of water is stored. These dams are liable to cause ecological imbalance and may cause severe flood situation if breached. Similarly the greenhouse effect would bring global warming which may cause serious disasters in future.[1]

Famine Food

During the period of famine, the people affected are forced to utilize such plant and animal species which do not constitute the normal food in food sufficiency situation. Roots, bark of the stem, leaves, flowers, and seeds of these non-conventional plants contributed a lot in saving the life of hundreds of people of famine-affected regions of the Indian subcontinent. When even the non-conventional plant species were not available, the non-vegetarian population also utilized those animals which are not normally consumed as food and thus the survival was more in non-vegetarians as compared to vegetarian people. Some of the non-conventional plant species utilized as food in famine condition are given in Table 2.

There is no record available that how many people suffered due to ailments while discovering the edibility of the non-conventional plants. After rigorous screening, ultimately they succeeded to discover these plants for their survival during famine conditions.

It is interesting to note that several non-conventional plants now have become very important due to their diversified utility, taste, and medicinal value. *Bilva* (*Aegle marmelos*) is known for its medicinal value in Ayurveda. *Ker* (*Capparis decidua*), *lasoda* (*Cordia obliqua*), *kachri* (*Cucumis callosus*), and pods of *khejri* (*Prosopis cineraria*) are used to prepare "*Pachkuta*", a traditional vegetable in Rajasthan. On the occasion of *Sheetalashtami* (a festival to appease the goddess of small-pox), this vegetable is prepared in majority of families. In addition *C. myxa* and pods of *P. cineraria* are used to prepare pickles which fetch good price.

1. There are two meanings of the term "greenhouse effect". There is a "natural" greenhouse effect that keeps the Earth's climate warm and habitable. There is also the "man-made" greenhouse effect, which is the enhancement of Earth's natural greenhouse effect by the addition of greenhouse gases from the burning of fossil fuels (mainly petroleum, coal, and natural gas). In order to understand how the greenhouse effect operates, we need to first understand "infrared radiation". Greenhouse gases trap some of the infrared radiation that escapes from the Earth, making the Earth warmer than it would otherwise be. You can think of greenhouse gases as sort of a "blanket" for infrared radiation – it keeps the lower layers of the atmosphere warmer, and the upper layers colder, than if the greenhouse gases were not there.

   Global warming is caused by several causes such as pollution from factories, carbon dioxide from rotting trees, the burning of coal, natural gasses and fossil fuels lead to methane traveling into the Earth's atmosphere, any transportation vehicles, water vapor, and many other little things, which contribute to make global warming even worse.

Table 2. Plant species utilized as food during famines in the Indian subcontinent.[1]

Latin name	Sanskrit name[2]	Plant part used in state/region
Alismataceae		
Sagittaria sagittifolia	*Chotakut* (H)	Tubers: all regions
Amaranthaceae		
Achyranthes aspera var. *porphyristachya*	*Apamarga, latjira* (H)	Leaves and seeds: Deccan, Uttar Pradesh, Bihar, Rajasthan
Amaranthus blitum var. *oleracea*	*Marisha*	Herb: Deccan, Rajasthan
Amaranthus cruentus	*Rajgiri*	Herb: Rajasthan
Amaranthus tricolor	*Tanduliya*	Leaves: Rajasthan
Celosia cristata	*Shikha, sushikha*	Leaves and shoots
Anacardiaceae		
Mangifera indica	*Amra*	Kernels
Rhus mysurensis	*Dansar* (H)	Leaves and roasted fruits: Rajasthan
Spondias pinnata	*Amrataka*	Leaves and green fruits: Deccan
Apocynaceae		
Carissa spinarum	*Karamardika, karaunda* (H)	Fruits: Rajasthan
Asclepiadaceae		
Ceropegia bulbosa	*Patalatumbi, gilodya*	Roots and fleshy leaves: Deccan
Bambusaceae		
Bambusa vulgaris		Young shoots: Uttar Pradesh, Bihar, Rajasthan
Burseraceae		
Boswellia serrata	*Salakhi, sallaki*	Flowers and seeds by Bhils; fruit-soup in Orissa
Cactaceae		
Opuntia elatior	*Nagaphana*	Fruits: Uttar Pradesh, Bihar, Rajasthan
Caesalpiniaceae		
Cassia occidentalis	*Kasamarda*	Leaves: Uttar Pradesh, Bihar, Rajasthan
Tamarindus indica	*Amlika, tintili*	Herb: Deccan
Cannaceae		Leaves and seeds: Deccan, Rajasthan
Canna orientalis	*Sarvajaya*	Tuberous rhizomes
Capparidaceae		
Capparis decidua	*Karira, ker* (H)	Fruits and floral nectar: Rajasthan
Chenopodiaceae		
Chenopodium album	*Vastuka, vastukah*	Leaves and tender twigs: Rajasthan
Suaeda maritima	*Khari lani* (H)	Leaves which reportedly saved thousands of lives in 1791 to 1793 AD

continued

Table 2. *continued*

Latin name	Sanskrit name[2]	Plant part used in state/region
Cleomaceae		
Gynandropsis pentaphylla	*Tilparni*	Leaves
Commelinaceae		
Commelina forskalli	*Kankawwa*	Leaves and seeds: Rajasthan
Compositae		
Launaea sarmentosa (syn. *L. pinnatifida*)	*Pithari*	Leaves (some doubt about identity)
Convolvulaceae		
Ipomoea aquatica	*Kalambi*	Herb: Deccan, Bengal, Rajasthan
Cruciferae		
Brassica spp.	*Rajika, sarshapa*	Leaves
Cucurbitaceae		
Citrullus colocynthis	*Indra*	Seeds as flour (documented in 17th century): Rajasthan
Citrullus lanatus	*Motira* (H)	Fruits and seed pulp: Rajasthan
Cucumis callosus	*Ervaru, karkati, kachri* (H)	Ripe fruits: Rajasthan
Momordica dioica	*Karkotaki, kakoda* (H)	Fruits: Rajasthan
Dioscoreaceae		
Dioscorea bulbifera	*Varahi, ratalu* (H)	Boiled tubers pounded and mixed with flour: Rajasthan
Ehretiaceae		
Cordia obliqua	*Laghushita, lasoda* (H)	Flowers and fruits: Deccan, Rajasthan
Gramineae		
Cenchrus biflorus	*Bhurata* (H)	Seeds in northern India, especially Rajasthan since 17th century
Cenchrus setigerus	*Anjan* (H), *kala, dhaman* (H)	Seeds: Rajasthan
Cynodon dactylon	*Durva, durvah*	Seeds and culm (fodder): Uttar Pradesh, Bihar
Echinochloa colona	*Sawa* (H)	Seeds: Deccan, Rajasthan
Lasiurus hirsutus	*Sevan* (H)	Seeds and fodder: Rajasthan
Zea mays	*Makaya, yavanala*	Cobs: Uttar Pradesh, Bihar
Liliaceae		
Aloe barbadensis	*Kanya, kumari*	Tender leaf pith and pulp: Uttar Pradesh, Bihar, Rajasthan
Aloe indica	*Ghrita-kumari*	Leaf-buds
Urginea indica	*Jangli-piyaz* (H)	Leaves: Deccan
Mimosaceae		
Acacia leucophloea	*Arimeda, safed kikar* (H)	Bark (ground into flour) and young pods: Rajasthan
Acacia senegal	*Kumat* (H)	Seeds as vegetable: Rajasthan
Albizia procera	*Kinthi*	Leaves eaten in Orissa, Uttar Pradesh, Bihar
Prosopis cineraria	*Sami, khejri* (H)	Pods, bark, and leaves as fodder: Deccan, Rajasthan (1899)

continued

Table 2. *continued*

Latin name	Sanskrit name[2]	Plant part used in state/region
Moraceae		
Ficus benghalensis	*Nyagrodha, vata*	Fruits: Uttar Pradesh, Bihar, Rajasthan
Ficus glomerata (syn. *F. racemosa*)	*Udumbara, udumbarah*	Fruits: Deccan, Rajasthan
Ficus religiosa	*Asvattha, pippala*	Fruits: Deccan, Uttar Pradesh, Bihar
Musaceae		
Musa superba	Wild banana (E)	Leaf-sheath: Deccan
Naucleaceae		
Anthocephalus cadamba	*Kadamba, nipa*	Fruits: Deccan
Nymphaeaceae		
Nymphaea stellata	*Nilotpala, nilkamal* (H)	Roots and seeds
Palmae		
Phoenix sylvestris	*Kharjura*	Fruits and leaf-buds: Deccan, Rajasthan
Papilionaceae		
Crotalaria juncea	*Sana, sanah*	Leaves and pods: Deccan
Indigofera cordifolia	*Godali* (H)	Seeds mixed with grain for flour in Rajasthan
Sesbania bispinosa	*Jayanti, dhencha*	Seeds: Deccan, Rajasthan
Polygonaceae		
Calligonum polygonoides	*Phog* (H)	Buds: Rajasthan
Rhamnaceae		
Ziziphus mauritiana	*Badara, kola*	Dry fruit powder: Deccan, Rajasthan
Rutaceae		
Aegle marmelos	*Bilva*	Fruits
Sapotaceae		
Madhuka indica (syn. *Bassia latifolia*)	*Madhuka*	Dried flowers and fruits: saved lives of thousands in Bihar in 1873–1874 AD
Taccacae		
Tacca leontopetaloides	Indian arrowroot (E)	Roots: Deccan
Verbenaceae		
Premna latifolia	*Agnimantha, bakar* (H)	Leaves: Uttar Pradesh, Bihar
Premna obtusifolia	*Agnimantha, agetha* (H)	Leaves: Uttar Pradesh, Bihar

1. For complete list see Nene (2004), Asian Agri-History, Vol. 8 (4), pp. 267–278.
2. H = Hindi; E = English.

Similarly, the flour of *rajgiri* (*Amaranthus cruentus*) is used during religious fasts which is costlier than the traditional cereal flour. *Ratalu* (*Dioscorea bulbifera*) and *kakoda* (*Momordica dioica*) have now become very delicious vegetables and are consumed by urban population. *Karaunda* (*Carissa spinarum*) fruit being sour in taste is mixed with green chili to make good and tasty pickle.

Questions

1. Famines have occurred in the Indian subcontinent since:
   (i) Vedic times (ii) Mahabharata times (iii) Medieval times (iv) British occupation
2. According to records available famines were rare during:
   (i) 500 BC–500 AD (ii) 500–1000 AD (iii) 1000–1500 AD (iv) 1500–2000 AD
3. Which of the current states of India had maximum number of famines in recorded history?
   (i) Deccan (ii) Punjab (iii) Gujarat (iv) Rajasthan
4. Which region of India suffered from lowest number of famines?
   (i) Kashmir (ii) Delhi (iii) Assam (iv) Mysore (Karnataka)
5. The well-known Durgadevi's famine occurred during:
   (i) 1341–1342 AD (ii) 1341–1351 AD (iii) 1296–1317 AD (iv) 1396–1408 AD

CHAPTER 18

FESTIVALS AND AGRICULTURE

"Our life is agriculture based, our festivals are agriculture based, our food habits and way of the life are also agriculture based. Agriculture is not only an important occupation of the people, but also way of life, culture, and custom."

India is a land of festivals and festivities. These festivals are basically meant to express gratitude to the forces of nature that help the humans to produce wealth of food from cultivating the land, to procreate and bring to life best offspring, to harness energy resources from water, air, and solar energy. Thus Sun, air, water (rivers, seas, and ocean), trees, and forest (that give us wood and herbs and roots as medicines) became objects of worship. Festivals became not only the personal, family, and social occasions of fun and merriment, but also events of prayer and worship of various gods and goddesses.

Thus to supplement this spiritual drive, various functions at family and social level are organized that gave variety and entertainment in life. Before the advent of scientific and technological revolution, these activities (till recent times), were restricted and related to agriculture, food processing, and cottage industries. Social festivals were organized at the beginning and end of farming activities. At the beginning, due to vagaries of nature, people conducted mostly prayers and worship of village and personal deities. This was to propitiate gods of rains, weather, etc. and to pray to them to shower their grace in the form of good rainfall and save their crop from pests and other catastrophes. At the end of harvesting, however, once their prayers were rewarded with bountiful grains – cereals, lentils, maize, and oilseeds – their joy knew no bounds. The young and elderly, men and women, boys and girls, all expressed their joy and gratitude to mother earth. These took the form of celebrating festivals. More importantly, these occasions for rejoicing obtained a seasonal regularity. With the repetition of the same festival, at around the same time – year after year helped the festivities to take on a definite pattern. It was at this stage that the practices of observing festivals ceased to take place at a random frequency and began to take the form of a tradition. Festivals arose out of some necessity of day-to-day life of the hazy past and were later transformed into customs, due to which they obtained a changeless character. What began as a habit was transformed into a custom. This way, different customs and traditions came to be associated with different festivals.

Baisakhi and *Holi* in the Northwest, *Dasera* and *Diwali* (*Deepavali*) in mainland, *Pongal* and *Onam* in South, and several festivals in northeastern states of India are common festivals related with prosperity and fertility.

Festivals of Northeast India

The mystic region of Northeast India comprises seven states, popularly known as the seven sisters, which are Assam, Arunachal Pradesh, Mizoram, Nagaland, Tripura, Manipur, and

Meghalaya. These Northeast Indian states have always been abundantly favored by nature. The tropical forests are full of vast species of flora and fauna. Scarcely populated and mainly full of tribal population, these states always are on a celebration spree.

Nagaland

The predominantly tribal state of Nagaland is blessed with high mountains, deep valleys, and rich flora and fauna. Being inhabited by 16 tribes, Nagaland is a land of festivals. Some tribe or the other has a celebration throughout the year. Every tribe has its own festival. Several festivals are connected with agricultural activities such as reaping, sowing, and harvesting. *Moatsu* festival is performed by Ao Naga in May, after the sowing. People worship the deity, sacrifice animals, and sing, dance, and make merry during the festival. Some of the important festivals celebrated by the tribes are *Sekrenyi* by the Angamis in February, *Moatsu* by the Aos in May, *Sukrunye* by the Chakhesangs in January, *Aoling* by the Konyaks in April, *Mimkut* by the Kukis in January, *Bushu* by the Kacharis in January, *Tuluni* by the Sumis in July, *Nyaknylum* by the Changs in July, *Tokhu Emong* by the Lothas in November, and *Yemshe* by the Pochurys in October.

Assam

A land nestled in myths and mysteries, lores and legends, Assam is almost another world, the gateway to the eastern states, the colored wonderland of India. Assam is a land of fairs and festivals. Most of the festivals celebrated in Assam have their base in the multifarious faith and belief of its inhabitants. The most important festival of Assam is the *Bihu*, the Assamese New Year Celebrations. This major festival of Assam is celebrated in three forms, the *Bohag Bihu* or *Rongali Bihu* in April, *Magh Bihu* or *Bhogali Bihu* in January, and *Kati Bihu* or *Kongali Bihu* in October/November. The most colorful is the Spring-Festival, *Rongali Bihu*, celebrated in mid April. Essentially a festival heralding the beginning of an agricultural season, the people of Assam enjoy it with dancing and singing. *Bhogali Bihu*, the harvesting festival is celebrated in mid January by community feasts.

Bihu is the biggest festival of the people of the Assam region. This is truly a regional festival, which brings a sense of solidarity and unity among the people of the Assam region. It comes thrice a year and marks the changes in the seasons. The first of the three "*Bihus*" falls on "*Chait Sankranthi*". It is called *Bihag Bihu* or *Rongali Bihu*. In fact, *Bihu* is a festival to celebrate fertility. *Rongali Bihu* is the most festive and joyful of all the *Bihus*. Other *Bihus* are known as *Magh Bihu* and *Kati Bihu*.

The *Rongali Bihu* is a Spring New Year and agriculture festival, all rolled into one. The first day of *Rongali Bihu* is known as *Gori Bihu* and is reserved for cattle rites. Household cattle get special attention and they are decorated with colorful garlands of flowers and given good food. The next day is called "*Manuh Bihu*". Paying homage to elders is customary on that day. On this day special meal is prepared with *chivra* (beaten rice), curd, and sweets. An attractive feature is the offering of a present called "*Bhiguwan*", which consists of a napkin woven by women in the family loom. The next day is "*Gosain Bihu*", which is reserved for religious

services. On the seventh day the people prepare seven types of leafy vegetables called "*Sat Sak*". Games and sports are also a necessary part of the *Bihu* celebrations. Children join them with great fervor.

The harvest festival celebrated in winter is the *Magh Bihu* when the crops have been harvested. Feasting forms the main feature of this *Bihu*. It is also connected with fire rites and the lighting of bonfires. On the *Bihu* eve, every household has a special meal of fish and meat. Groups of young people and children hold community feasts in temporary structures made of dry hay and bamboo sticks.

The *Bihu* specialties among food items are "*chivra*" (beaten rice), "*pitha*" (rice cakes), "*laru*" (sweet balls) of various kinds. These are eaten as mid-day meals. It is also customary for the young to get blessings from the older members of the family.

The last of the *Bihus* is the "*Kati Bihu*" which is a one-day celebration. It falls around October–November, when the paddy crops are yet to mature and the granaries are almost empty. Hence it is called "*Kangali*" or poor *Bihu*. Naturally there is no feasting on this day. Special *Tulsi Pujas* are held on this day.

Arunachal Pradesh

Arunachal Pradesh is one of the most sparsely populated states on the eastern tip of India, sharing its borders with China, Bhutan, and Myanmar. Known as the land of rising Sun of India, it is a fertile land with five rivers flowing through the state. Mainly inhabited by various tribes, the festivals here are based on nature and agriculture and dance is the soul of all these festivals. Agriculture being the basic means of livelihood, the festivals having connection with agriculture are celebrated in bigger scale either to thank God for the providence or pray for good harvest. Animal sacrifice is a common ritual in most of the festivals in Arunachal Pradesh. Throughout the year festivals are celebrated by one or the other tribes. Because of this fact, Arunachal Pradesh may also be called the land of festivals.

Choekhor is an important festival after the crops are sown and at the time of little agricultural activity. In the seventh month of lunar calendar, a rite known as "*Choekhor*" is organized in the villages by the entire village community with the aim of offering supernatural protection to the crops sown, for good harvest, and to drive away evil spirits. Another important festival is *Tamladu*, essentially celebrated by the *Digaru Mishmis* tribe. During the festival, prayers are offered to the God of Earth and the God of water for protection against natural calamities. The supreme, Lord *Jebmalu*, is worshiped for welfare of human beings, the standing crops, and domestic animals.

Mizoram

Mizoram is on the southern tip of the northeastern region clamped between Myanmar and Bangladesh. The Mizo community is mostly follower of Christianity. The festivals of Mizoram are related to the agricultural activities that bring forth the vibrancy and the liveliness that the

people of Mizoram possessed. Some of the major festivals in Mizoram are *Chapchar Kut, Mim Kut, Pawl Kut*, and *Thalfavang Kut*.

Chapchar Kut or Spring Festival is the most popular festival, celebrated after completion of the most arduous task of jungle clearing for *jhum* (shifting cultivation) operations. On this day, people of all ages, young and old, men and women dressed in their respective colorful costumes and head-gears, assemble and perform various folk dances, sing traditional songs, accompanied by the beating sound of drums, gongs, and cymbals. *Mim Kut* and *Pawl Kut* (November/ December) festivals are also part of the tourist season. It is celebrated for the completion of the harvesting season. During these festivals, the various folk dances, exulting songs, and energetic games are performed. When the festival takes place, the entire community also joins in with great enthusiasm, joy, and feasting. During these festivities '*tingtang*' (guitar) and '*phenglawng*' (flute) which are the indigenous musical instruments also act as rhyme and musical accompaniments to the various dances.

Tripura

Tripura is one of the tiniest states in the Indian subcontinent. The tribes of Tripura with their life centered round growing paddy have a festival calendar which reflects various phases of the crop cycle. *Makita*, the principal agricultural festival is celebrated in winter at the time of harvest of paddy.

In the months of *Ashwin–Kartika* (October–November) the paddy is harvested. To separate grains from husk the paddy is thrashed by beating or trampling. This activity takes the form of young tribal dancing ecstatically on paddy ears spread in the courtyard. The dancing and merrymaking with some *pujas* for thanksgiving forms the *Mamita* festival.

The main deities *Mailooma* (Goddess of rice) and *Khoolooma* (Goddess of cotton) are offered the first harvest. Other deities like *Akhartra, Bikhirtra, Matai Kutar, Matai Katarma, Sangrang, Tuima, Nokchumatai, Buracha*, and *Sekaljook* are also worshiped. There is no specific date or timing. Every family decides the day according to the harvest schedule.

Manipur

Manipur is well known as the Paradise of Eastern India. Manipur is where Mother Nature has bestowed her bounty extra-generously. All that can fascinate a tourist is what Manipur is all about. The world famous Manipuri Dance has originated from the temples of this exotic state in Northeast India. Celebrated for five days commencing from the full moon day in February–March, *Yaoshang* is the premier festival of Manipur. The *Thabal Chongba*, a kind of Manipuri folk dance, is particularly associated with this festival. *Cheiraoba*, Manipur New Year, is celebrated in April. People clean and decorate their houses and prepare special festive dishes, which are first offered to various deities. A part of the ritual entails villagers climbing the nearest hilltops in the belief that it will enable them to rise to greater heights in their worldly life. This festival is celebrated by all irrespective of any religion. Other Hindu festivals such as the *Durga Puja* in October and the *Jagannath Yatra* in July also take place.

Meghalaya

'Megha' means 'clouds' and as the name suggests, Meghalaya gets torrents of rain. It is a region of great scenic beauty. The three important tribes in Meghalaya are Garos, Khasis, and the Jaintias. They have their own festivals and fairs that signify agricultural activities of sowing and harvesting. Among the Garos, the most important festival is the *Wangala* or the hundred-drum festival held from November to December. This is a harvest festival celebrated in honor of the Sun God. *Nongkrem* Dance is held annually for five days by the Khasis. It is a religious festival for thanksgiving to God Almighty for good harvest and to pray for peace and prosperity in the community. It is celebrated in November. *Behdienkhlam* is the most important dance festival of the Jaintias and is celebrated after the sowing period is over. At Jowai town, this festival is celebrated in July.

Harvest Festival in Tamil Nadu

Pongal is a harvest festival. In an agriculture-based civilization, the harvest plays an important part. The farmer cultivating his land depends on cattle, timely rain, and the Sun. Once a year, he expresses his gratitude to these during the harvest festival. With the end of the wet month of *Margazhi* (mid December to mid January) the new Tamil month of *Thai* heralds a series of festivals. The first day of this month is a festival day known as "*Pongal* Day". *Pongal* means the "boiling over" of milk and rice during the month of *Thai*.

According to the calendar based on the solar system the year is divided into two halves following the apparent movement of the Sun Northwards and Southwards. The former is termed *Uttarayan* and the latter is *Dakshinayan*. The beginning of the *Uttarayan* event thus is celebrated as *Pongal*. The four-day celebration of *Pongal* marks a period of plenty, peace, and happiness. It is held to honor the Sun for a bountiful harvest. Families gather to rejoice and share their joy and their harvests with others and milk and rice are offered to the Sun.

Festivals Across the Nation

Deepavali

Worship of the Goddess of wealth (Lakshmi), observance of the New Year, and performance of *Aarti* (a ritual that combines worship and adoration) are a part of *Deepavali* festival. On the second day of *Deepavali* (*Kali Choudas*) or *Diwali*, a ritual that is strongly suggestive of the origin of *Deepavali* as a harvest festival is performed. On this day delicacies are prepared from pounded semi-cooked rice (called *poha* or *pova*). This rice is taken from the fresh harvest available at that time. This custom is prevalent both in rural and urban areas especially in Western India. In rural areas, *Diwali* signifies harvest as it is celebrated sometime in October/November, which coincides with the end of the harvesting season.

Padava

The association of the New Year termed *Padava* or *Padavo* with *Diwali* also substantiates the harvest festival theory. The end of one harvest and beginning of another meant the end of one

cycle of activity and the beginning of another, as all activities in an agrarian economy must have been linked-up largely with agriculture. Hence, it was quite natural to look upon a festival that was observed at the end of one harvest season and the beginning of a new one, as a festival heralding the beginning of a new year.

Gudi Padava or *Ugadi* which is also looked upon as a new year in some parts of India (Maharashtra, Karnataka, and Andhra Pradesh) also occurs at the end of another cropping season (the *rabi* season) and coincides with a harvest.

Navaratra

The *Garbha* Dance in Western India is performed around a pot containing a lamp. The word "*Garbha*" by which the pot as well as the dance is known is etymologically close to the word *Garbha* meaning womb. In this context the lamp in the pot, symbolically represents life within a womb. Another prevalent practice is of sowing pulses, cereals, and other seeds on the first day of this festival in a pot, which is watered for nine days at the end of which the seeds sprout. This pot is worshiped throughout the nine days. This custom is also indicative of fertility worship.

Akshyaya Tritiya

Akshyaya Tritiya is exclusively an agricultural festival celebrated in April. On this day farmers in Rajasthan ceremonially start sowing seeds in the field, especially paddy. Early in the morning, farmers in their respective homes arrange the materials for the ritual. After ablution in a river or tank they wear new clothes and carry the seeds in new baskets to the field. In the field, farmers themselves make offerings to Lakshmi, the Goddess of wealth. Then they sow seeds ceremonially. Prayers are arranged in respective homes, to the Goddess for a rich bumper crop. In western Orissa, this festival is called *'Muthi Chhuan'*. Eating of green-leaves (*shag*) is forbidden for the day. The festival is observed by all farmers irrespective of their caste and creed. Religious scriptures testify that Ganga, the sacred river of India landed on the Earth on this day from Heaven. She is the perennial source of water, which is essential for agriculture. Therefore, this auspicious day was chosen to start sowing seeds.

Basant Panchami

In the end of winter and the beginning of spring when nature is in a state of joyous being, an agricultural festival is traditionally celebrated, and importantly, in veneration of Sri Saraswati, Goddess of learning and wisdom. The ancient Hindu calendar started with this season. *Basant Panchami* or *Sri Panchami* is celebrated on the fifth day of *Magha* according to the lunar calendar, which is in February.

When the fields ripple with the brilliance of mustard flowers, the festival of *Basant Panchami* is traditionally celebrated with an abundance of the yellow color, in dress, festive decorations, and offerings of sweets. This festival marks the beginning of the agricultural season. It is celebrated in different ways in different parts of India, both as an agricultural festival and dedicated to the Goddess of learning.

Baisakhi

The festival of *Baisakhi* is celebrated predominantly in North India to inaugurate the New Year and to celebrate the success of farming. *Baisakhi* is celebrated on April 13th when Sun enters into Aries (*Mesha*) to augment the new cycle. Every village is decorated with banners, garlands of flowers, and grain tops. Aroma of sweet and curry dishes fills every house from one street to another. Family members and friends are invited to celebrate the joy of good harvest. Family deity is worshiped and blessings are showered on young ones. The festival is celebrated with gusto particularly in Punjab. The Sikhs celebrate it with overtones of their own religious reasons as Guru Gobind Singh had established the *Khalsa Panth* on this day.

When the wheat crop is ready, no one can stop the vivacious Punjabi. The beat of the *dhol* makes adrenalin run in his veins and a full throated *kacchi pakki na vekh, jatta aai baisakhi* (don't mind if your crop is still not ripe, dance, it is *baisakhi*) rents the air, while the *jatta* (Punjabi young man) bursts naturally into *Bhangra*, responding to the rhythm of the beats of *dhol*. Many gestures in *Bhangra*, *Gidda, Jhhummar*, and *Ghoomar* convey the skills and chores involved in the entire process of farming that leads to the day of happy harvesting. Dressed in their colorful best, the farming community, the dancers, and drummers challenge each other to continue the dance. The scenes of sowing, harvesting, winnowing, and gathering of crops are expressed in zestful movements of the body to the accompaniment of ballads. Fairs are organized at almost all towns in Punjab, where besides other recreational activities, wrestling bouts are also held. Though *Baisakhi* is celebrated in the entire North, where it is observed more as a beginning of the solar new year, it is only in Punjab that it has grown beyond a ritual of an agricultural base and the newly-wed couples ask for happiness and prosperity. The holy *Markandaya* fair is held near Bilaspur and the *Rohru Jatra* is held in honor of the deity *Shikhru*. This is also the time when fishing and low altitude trekking raises their winter barriers, while the Spring Festival is celebrated in Kullu from 28 to 30 April. *Baisakhi* day coincides with the New Year of the Tamils.

Minjar fair

Chamba's famous *Minjar* fair is celebrated sometime in August to enjoy the bounty of nature, and prayers are offered for a good harvest. In this very special festival that was promoted by the erstwhile kings of Chamba in a classic fashion to promote and preserve special culture of Chamba, *minjars* or maize shoots or silken strands are cast on the waters of the river Ravi by the denizens of Chamba who come attired in their very best and the town immerses itself in a week long celebration. Girls married outside Chamba return to their town so as not to miss out on the festivities, so close to the hearts of the residents of Chamba.

Questions

1. Which tribe of Nagaland celebrates *Moatsu*, a post-sowing festival?
   (i) Kukis (ii) Angamis (iii) Ao Naga (iv) Lothas

2. Which state of India celebrates *Rongali Bihu* in a big way in mid April every year?
   (i) Manipur (ii) Assam (iii) West Bengal (iv) Tripura
3. Which community of Meghalaya celebrates annually the *Nongkrem* Dance?
   (i) Khasis (ii) Garos (iii) Jaintias (iv) Nagas
4. In which state *Chapchar Kut* a popular spring festival is celebrated?
   (i) Arunachal Pradesh (ii) Manipur (iii) Mizoram (iv) Nagaland
5. Which state of India celebrates the *Pongal* festival (harvest festival)?
   (i) Kerala (ii) Andhra Pradesh (iii) Karnataka (iv) Tamil Nadu

CHAPTER 19

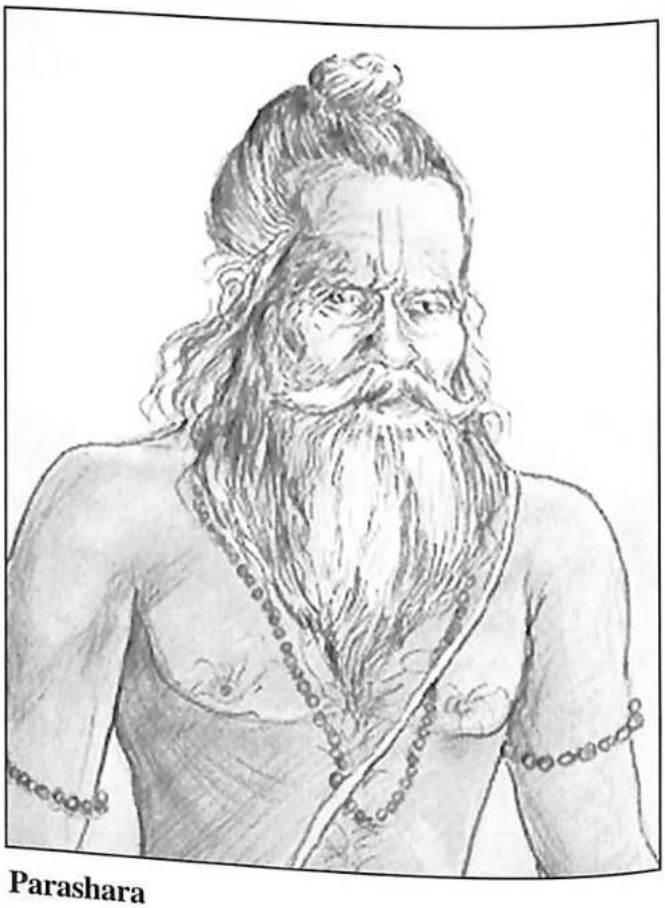
PIONEERS IN AGRICULTURE

Until 1996, hardly any textbook referred to real pioneers of Indian agriculture. The efforts made by the Asian Agri-History Foundation (AAHF) since 1996 have revealed the names of such pioneers who knew farming very well and wrote texts in Sanskrit mostly in the *Pothi* style. These pioneers were sages, physicians, learned scholars, and administrators. The pioneers discussed in this chapter are:

- Parashara (c. 400 BC)
- Kautilya (321–296 BC)
- Varahamihira (505–587 AD)
- Kashyapa (c. 800 AD)
- Surapala (c. 1000 AD)
- Sarangadhara (1283–1301 AD)
- Chakrapani Mishra (1577 AD)

Parashara

The manuscript Krishi-Parashara was written by Parashara, which is probably the first-ever textbook on agriculture in which the information is logically organized in chapters. The chapters deal with tools and implements especially the plow, forecasting of rains, importance of good management in agriculture, management of cattle, seed collection and storage, etc.



Parashara

Kautilya

Kautilya or Chanakya or Vishnugupta was chief advisor of Chandragupta Maurya. He wrote a treatise popularly known as "Kautiliya Artha-sastra".

Kautilya gave great emphasis to agriculture and suggested a separate post of Head of Agriculture (Superintendent) and named it "*Sitadhyaksha*" who was made accountable to state and agriculturist for all the agricultural

practices. He gave importance to animal husbandry, construction of dams, and allotment of land to landless persons. He also described the technique for measuring rainfall in detail, seed procurement and treatment, cropping pattern and methods and time of harvesting of crops, and policies of engagement of laborers for different agricultural operations. He mentioned the importance of animals, particularly the cow.

Varahamihira

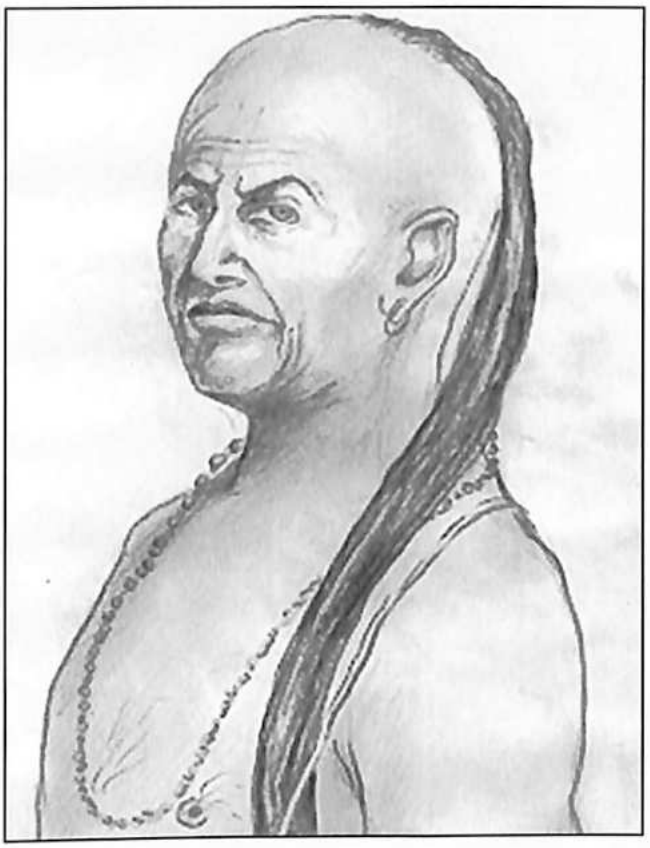
Varahamihira wrote Brihatsamhita that deals with widely ranging subjects as astronomy, physics, geology, horticulture, archaeology, etc. It also contains a chapter titled Vrikshayurveda. This clearly proves that the science of Vrikshayurveda was well-developed prior to the sixth century AD.

Kashyapa

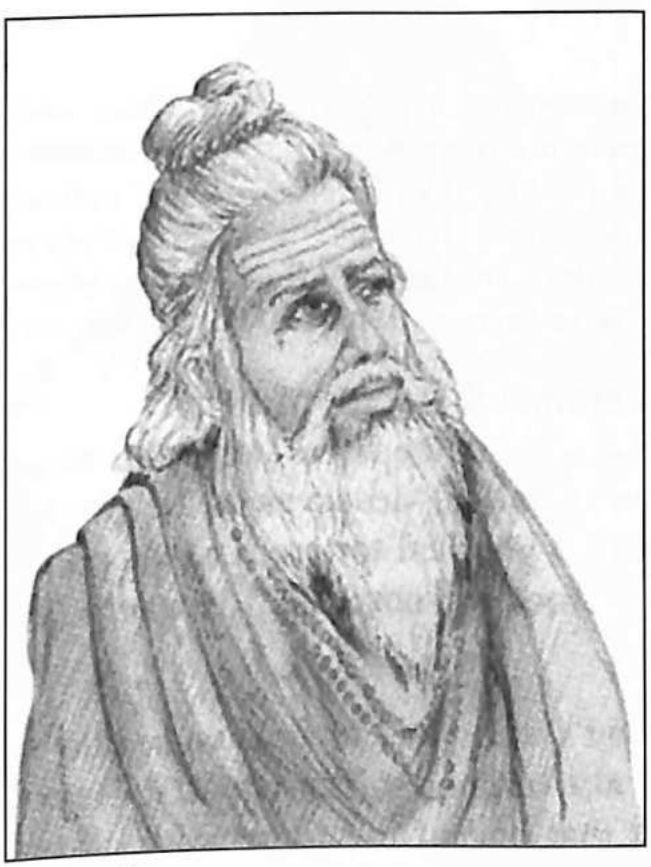
Kashyapa has written an excellent text on agriculture, which covers in detail not only irrigated rice production in India but also other aspects such as emphasis on strong support to agriculture from the ruler, participation of people of all castes in farm-related activities, cattle management, soil properties, growing pulses on uplands, growing vegetables, fruits, spice crops, and ornamental plants, growing trees, laying out gardens, marketing, and even mining.

Surapala

Surapala has compiled a text titled Vrikshayurveda which means "The Science of Plant Life". It mainly deals with various species of trees and their healthy growth and productivity. The text mentions about 170 species of plants, including herbs, shrubs, and trees. The text in various chapters deals with

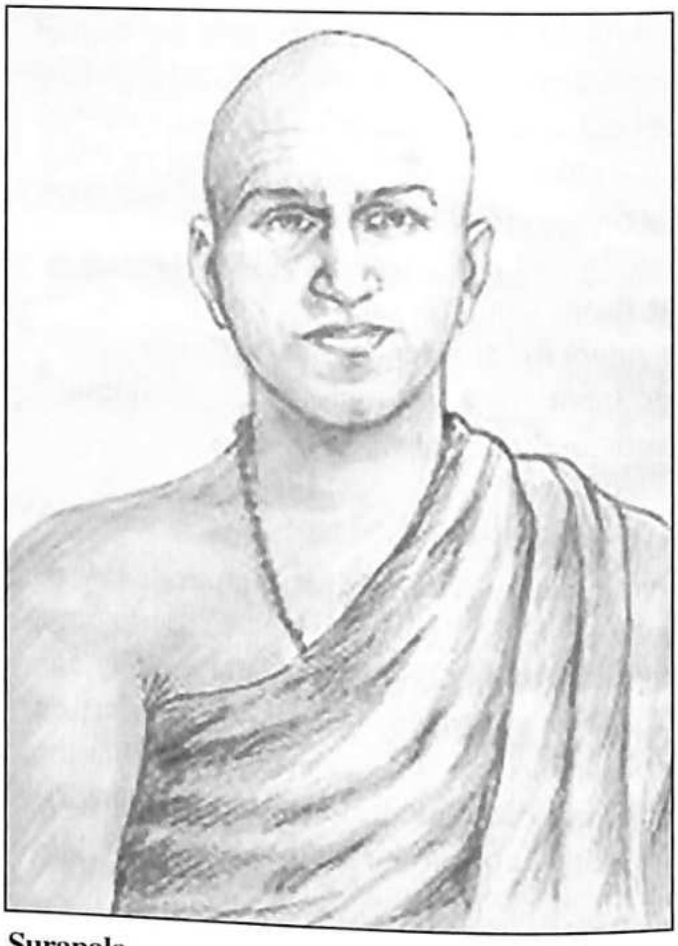


Kautilya



Varahamihira

Kashyapa



Surapala

the raising of orchards, agri-horticulture, and tree planting near houses. Special references are made on procuring, preserving, and treatment of seeds and planting materials; preparation of pits for planting; selection of land (soil), methods of irrigation, and ways to locate groundwater; nourishment and fertilizers; diseases of plants and plant protection; laying out of gardens and orchards; creation of agricultural/horticultural wonders; use of plant species as indicators of crop and animal production; and description of sacred plants.

Sarangadhara

Sarangadhara compiled an anthology, "Sarangadhara-Paddhati", dealing with varied subjects, one of which was "Upavanavinoda" (a text on arbori-horticulture). Upavanavinoda deals with the following topics:

- Glory of trees
- Selection of soils for planting various trees
- Classification of plants
- The process involved in sowing of seeds and planting
- Watering
- Examination of soils where wells are to be dug

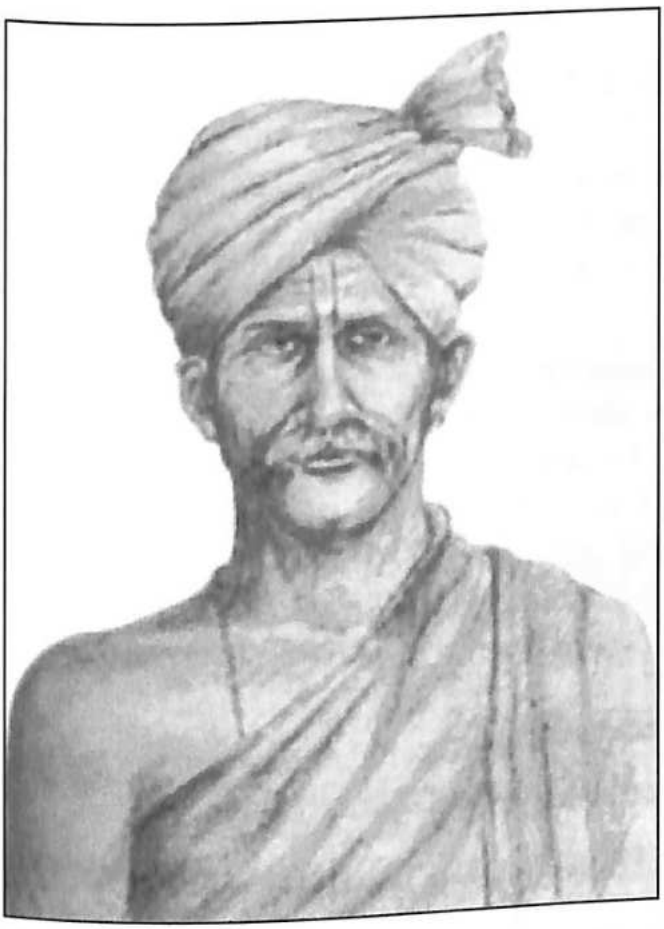
- Rules for the nourishment of the plant
- Pest and disease management
- Botanical marvels

Chakrapani Mishra

Chakrapani Mishra worked under the patronage of Maharana Pratap, the great ruler of the Mewar region of Rajasthan in Western India. Chakrapani Mishra wrote a classic "Vishvavallabha", which deals with various aspects of agriculture with a focus on the Mewar region, which probably included adjacent areas of the present-day Gujarat and Madhya Pradesh. The following topics relate well to the Mewar region:

- Detection of groundwater in arid, semi-arid, and moist regions, and hills
- Construction of water reservoirs
- Types of soils
- Crops to be grown

Besides these, Chakrapani has also mentioned about protection of saplings, nourishment, disorders and treatments of plants, wonders of seeds and plants, etc.



Sarangadhara

Chakrapani Mishra

Questions

1. Who among the following are considered pioneers of Indian agriculture?
   (i) Parashara (ii) Kautilya (iii) Charaka (iv) Surapala
2. Which is the world's first-ever text on basic agriculture?
   (i) Brihatsamhita (ii) Vrikshayurveda (iii) Krishi-Parashara (iv) Vishvavallabha
3. Who suggested first the position of Superintendent for Agriculture or *Sitadhyaksha* for a state?
   (i) Surapala (ii) Bhattopala (iii) Sarangadhara (iv) Kautilya
4. Who among the following first described the rice cultivation in detail?
   (i) Chavundaraya (ii) Chakrapani Mishra (iii) Kashyapa (iv) Susruta
5. Who described the detection of underground water?
   (i) Chakrapani Mishra (ii) Kashyapa (iii) Kautilya (iv) Sarangadhara

APPENDIX 1

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APPENDIX 2

Chronology as adopted by the Asian Agri-History Foundation (2009)

Selected agri-history/ events/persons	Period	Remarks
Agastya, the sage	c. 5000 BC	Integrated North and South Indian cultures
Ain-i-Akbari	1590 AD	By Abul Fazl; crop and animal husbandry
Amarkosha – Amarsimha	c. 200 BC	A lexicon
Amarsimha	c. 200 BC	Lexicographer
Aranyakas	5500–5000 BC	Brahmana texts or the precursors of Upanishads
Atharvaveda	c. 1000 BC	The Fourth Veda
Bhadali (Bhaddri)	c. 1300 AD	Poetess who compiled couplets on agriculture
Bhagavad Gita	c. 1500 BC	Advice by Lord Krishna to Arjuna
Bhavamisra	c. 1600 AD	Ayurvedic expert; compiled Bhavaprakasha Nighantu
Bhavaprakasha Nighantu	c. 1600 AD	Ayurvedic Materia Medica
Bhoja (Parmara)	c. 1100 AD	Shalihotra manuscript of his time currently available
Brahmanas	6000–4000 BC	Commentaries on Vedas
Buddha	563–486 BC	Founder of Buddhism
Chakrapani Mishra	1577 AD	Author of Vishvavallabha
Charaka	c. 700 BC	Ayurveda pioneer expert
Chavundaraya II	1025 AD	A Kannadiga poet in the court of Western Chalukyas
Dara Shikoh's Nuskha Dar Fanni-Falahat	1650 AD	The Art of Agriculture compiled by Dara Shikoh
Dnyaneshwara-Sant	1275–1296 AD	Saint; wrote commentary in Marathi on Bhagavad Gita
Ghagh	c. 1300 AD	Poet who composed proverbs on agriculture
Harappan (early)	3300–2800 BC	A period in Indian civilization
Harappan (late)	1900–1400 BC	A period in Indian civilization
Indus-Saraswati Tradition	8000–1300 BC	A period in Indian civilization
Jainism	c. 600 BC	A religion that evolved in India
Jati Jaichand	1658–1714 AD	A Jain ascetic
Kalhana	1149–1150 AD	Author of Rajatarangini, a chronicle of the kings of Kashmir
Kalidasa	370–450 AD	A great poet
Kaliyuga begins	c. 3102 BC	Kaliyuga is one of the four Hindu eras
Kaliyuga calendar begins	c. 3100 BC	Kaliyuga – the 4th and last of the Ages cycle
Kashyapa	c. 800 AD	Author of Kashyapiyakrishisukti
Kashyapiyakrishisukti	c. 800 AD	A classical treatise on agriculture
Kautilya	321–296 BC	Author of Artha-sastra
Krishi-Parashara	c. 400 BC	A classical treatise on agriculture

continued

Selected agri-history/ events/persons	Period	Remarks
Kullavagga	c. 200 BC	Buddhist literature; mentions mildew and blight diseases of plants
Lokopakara	1025 AD	A Kannada poetry titled "For the benefit of people"
Mahabharata (events)	c. 3000 BC	An epic (Indian Journal of History of Science, July 1989)
Mahavira	527 BC	Mahavira founded the Jain religion; died in 527 BC
Manasollasa	1131 AD	Encyclopedic compilation for kings by Someshvardeva
Manusmriti	c. 200 BC	A treatise by Manu on code of conduct
Mriga.pakshi.shastra of Hamsadeva	c. 1300 AD	Documented behavior of animals and birds in the wild
Medhatithi	900 AD	The celebrated commentator on the Manusmriti; rational comments
Palakapya	c. 1000 BC	Author of Hastishastra (Science of Elephants)
Panini	c. 500 BC	The first Indian grammarian, known for his work, Ashtadhyayi
Parashara	c. 400 BC	Author of Krishi-Parashara
Patanjali	c. 200 BC	Grammarian; wrote Mahabhashya, a commentary on Ashtadhyayi and Yogasutra
Puranas	200 BC–750 AD	Popular encyclopedia of ancient and medieval Hinduism-18 no.
Ramayana (events)	c. 5000 BC	An epic with central focus on Lord Rama
Rigveda (events)	c. 8000 BC	The oldest of the four Vedas
Samaveda	c. 7000 BC	The third Veda, mainly for chanting
Sangam literature	100 BC–300 AD	Sangam in Tamil meaning academies
Saptarshi calendar (early) begins	6676 BC	A calendar that was followed in Kashmir
Sarangadhara	1283–1301 AD	A scholar in the court of Raja Hammira of Bundelkhand
Sayanacharya	c. 1400 AD	A scholar in Vijayanagar empire; wrote commentary on Vedas
Shaka (*Saka*) calendar begins	78 AD	A calendar, officially followed in India today
Shalihotra	c. 1800 BC	An expert on horses; wrote a treatise on management of horses
Shukraniti by Shukra	c. 100 AD	Wrote on science of polity and animal management
Someshvardeva	1126–1138 AD	A Chalukya (Western) king, author of Manasollasa
Surapala	c. 1000 AD	A physician in the court of Bhimapala; wrote Vrikshayurveda
Susruta	c. 400 BC	Pioneer surgeon, who wrote a medical treatise
Sutra literature	1500–800 BC	Deals with ritualism, individual and social behavior, philosophy, grammar

continued

Selected agri-history/ events/persons	Period	Remarks
Tholkappier	c. 200 BC	Wrote "Tholkappiam" in Tamil that contains information on agriculture
Tiruvalluvar	c. 70 BC	Author of the Tamil classic, The Kural or The Maxims of Tiruvalluvar
Tuzuk-i-Jahangiri	1605–1627 AD	Memoir of Mughal emperor Jahangir in India
Upanishads	1500–1000 BC	Last of the commentaries in the Vedic literature
Upavanavinoda	1300 AD	A treatise on horticulture by Sarangadhara
Vagbhata	c. 700 AD	Ayurveda specialist; wrote Ashtangahridaya/ Ashtangasangraha
Varahamihira	505–587 AD	An astronomer whose work Brihatsamhita became the foundation for posterity
Vikrama calendar begins	57 BC	A calendar still followed in parts of India and Nepal
Vishvavallabha	1577 AD	A treatise on water harvest and horticulture by Chakrapani Mishra
Vrikshayurveda by Surapala	c. 1000 AD	A treatise on management of trees and perennials
Yajurveda (events)	c. 7000 BC	The second Veda

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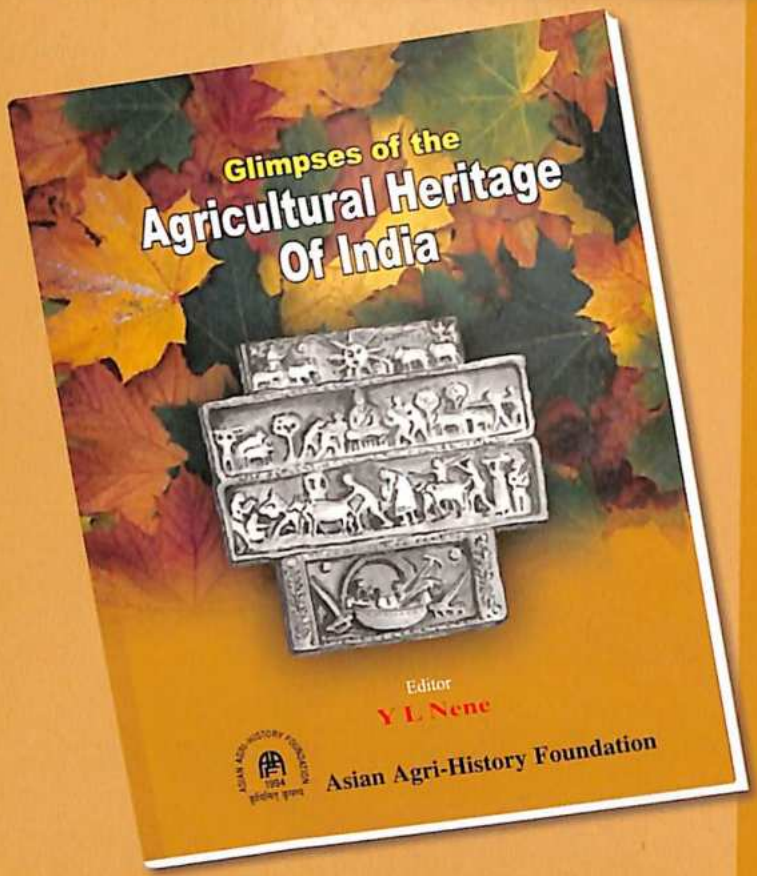

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